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MENSOR 12275

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PRECISION PRESSURE CONTROLLER

MODEL 12275

OPERATION MANUAL

PRECISION PRESSURE CONTROLLER

– PACKAGING INSTRUCTIONS –

THIS INSTRUMENT CONTAINS A HIGHLY
SENSITIVE PRESSURE SENSING ELEMENT.

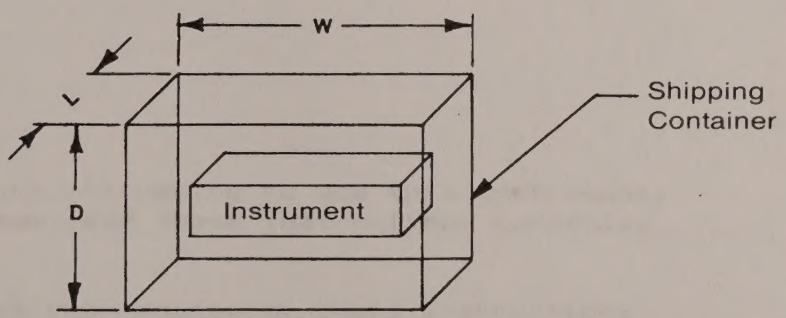
If this instrument is to be shipped by common carrier it should be packaged properly to minimize the risk of damage.

The important consideration in packaging is the density and resiliency of the packaging material. If the packaging material is too dense, it will transmit shock loads to the instrument. If the material isn't resilient, it will not return to its original form or shape after being subjected to a shock load and consequently will be useless when a second loading occurs. If the material is too resilient (urethane foam), damaging resonances can be transmitted to the delicate sensor.

DOMESTIC

The recommended method of packaging is to place the instrument in a container, surrounded on all sides with at least 4 inches of shock attenuation material such as PELASPAN (peanuts).

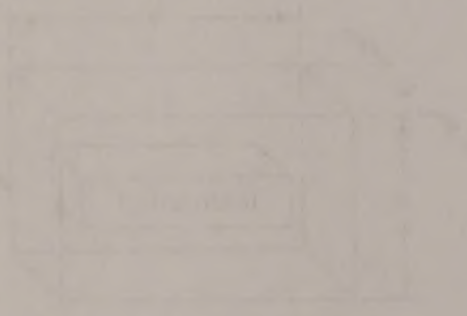
The minimum shipping container size for the PPC is 20" long, 15" wide, and 13" deep.



Instrument surrounded by 4"
cushion of packaging material

FOREIGN

Insert the above container into a second container, providing at least 2 inches of additional cushion material on all sides.



MENSOR PRECISION PRESSURE CONTROLLER
OPERATING INSTRUCTIONS
MODEL 12275

The Mensor Precision Pressure Controller precisely controls, measures and displays pressure. With proper care, this instrument will give you years of trouble-free performance.

Before attempting to use this instrument, please read these instructions carefully.

Additional copies of these instructions are available from Mensor Corporation.

Mensor is the registered trademark of Mensor Corporation, San Marcos, Texas

Manual P/N
A 12276001 C

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1.0 DESCRIPTION

The Mensor Precision Pressure Controller (PPC) precisely measures, displays and controls pressure. It operates by comparing the measured pressure, in the form of the voltage output of a precision pressure transducer, against a user-set pressure input voltage. The pressure input voltage is adjusted by means of two front-panel 10-turn pots. Either an analog or a digital remote control capability of the output pressure can be provided as an option.

In the MEASURE mode a digital panel meter displays the pressure directly in engineering units. In CONTROL the meter displays the pressure input voltage until the pressure output is within ± .01% of this voltage, and then five seconds after stabilization it switches to read pressure directly.

Pressure ranges available are from 0-5 PSI full scale to 0-500 PSI full scale in any engineering units. The PPC can be ordered as an absolute, differential or gauge instrument.

2.0 UNPACKING AND SET-UP

2.1 Unpacking

The Precision Pressure Controller (PPC) is shipped from the factory, ready for immediate use.

Keep the shipping and packing material until the PPC has been put into operation satisfactorily.

If there is any apparent damage to the PPC due to shipping, save all shipping materials and notify the carrier immediately. If requested Mensor will aid in the description and cost estimate for repair of the PPC in such cases, but the carrier should assume the cost.

2.2 Initial Checkout

After the PPC has been unpacked, operate it as described below to become familiar with its operation and to be sure no concealed damage has occurred. See Figure 2.2(A) for the front and rear panel controls and connections. Their functions are described in Table 2.2.

The required power source is 115V, 60 Hz, nominal. If the PPC is equipped for other line power, e.g., 220V, 50 Hz, this will be shown on a label near the fuses on the PPC rear panel.

Plug the PPC into the proper line power and switch it to MEASURE. A PPC with a differential transducer installed will indicate approximately 00000. One with an absolute transducer will display a reading representing barometric pressure, for example 30.00 for a 100" HgA. Remove any plastic thread protectors from the rear ports at this time.

NOTE: If the PPC responds to barometric pressure, the reading will change and follow barometric pressure changes which occur during these procedures.

The green LED on the front panel indicates that the PPC is displaying the actual measured pressure being applied to the rear pressure ports.

2.2.1 Setpoint Pressure (Monitor) Switch

Open the front panel door (unscrew the thumbscrew) and push the momentary setpoint monitor switch to the left (SETPOINT PRESSURE). The red LED should come on. This indicates that the displayed reading is the setpoint pressure that the PPC is set to control to.

2.2.2 Coarse and Fine Adjustments

While holding the switch to the left, turn the setpoint adjust COARSE and FINE pots on the front panel fully clockwise. (These are 10 turn pots.) The display should

indicate about 1% above the full scale range of the instrument. Turn the pots fully counter-clockwise. The display should indicate about 1% of span below zero. The COARSE pot is about 10% of span per turn, and the FINE pot is about 0.1% of span per turn.

Set the pots for a display of zero and release the switch.

2.3 Installation

The PPC as received is designed for either portable, bench mount or rack mounted use.

2.3.1 Bench Mount

The mounting surface should be level and free of vibration. The zeroing procedure, described in Section 3, should be done only after the PPC is in place on such a surface.

2.3.2 Rack Mount (optional)

Install the Mensor rack adapter in the rack. The PPC may be put into the rack adaptor either from the front or rear.

If front removal and installation is desired, the handle must be removed from the PPC cover. Also, remove the bar at the top of the opening in the rack adaptor. Slide the PPC through the opening, and replace the bar.

If the PPC is to be removed from the rear, the handle may be left on the PPC cover. Remove the clamp bracket from the rear of the rack adapter shelf, slide the PPC in so that the cover touches the front clamp bar, and replace the rear clamp bracket so that it retains the base plate of the PPC.

2.3.3 Pressure Ports

There are four pressure ports on the rear panel of the PPC. These ports are labeled SOURCE PRESSURE, EXHAUST, MEASURE/CONTROL PRESSURE, and REF (for reference). The standard fittings are female 1/8 NPT.

1) SOURCE PRESSURE: Connect a supply of dry instrument air or water-pumped nitrogen, at a pressure which is 5 to 10 psi above the maximum controlled pressure to this port. For a PPC with a 100 psi, or lower range regulator, the maximum supply pressure is 150 psi. For those with a higher range regulator the maximum pressure is 50 psi above the regulator range. At the recommended supply pressure, and with the regulated output pressure at full range, the maximum gas consumption is 3.5 standard cfh. This consumption reduces proportionally as the controlled output pressure is lowered.

2) EXHAUST: For controlled pressures of 0.1 psig or greater, this port may be vented to atmosphere. For lower controlled pressures, connect this port to a vacuum pump rated for at least 25 liters/minute at .05 In.HgA. Do not

leave this port blocked while the PPC is in the CONTROL mode.

3) MEASURE/CONTROL PRESSURE: This is the port which receives the unknown pressure in MEASURE mode and from which the known controlled pressure is obtained in the CONTROL mode.

4) REF: This port is not connected for absolute pressure PPC's. With differential PPC's this port is connected internally to the regulator reference pressure-chamber and to the transducer reference pressure-chamber. The digital readout will display the pressure differential between the REF port and the MEASURE/CONTROL PRESSURE port. In other words, with the PPC in CONTROL, the controlled output pressure will be the sum of the pressure at the REF port and the pressure shown by the readout counter.

The REF port is dead-ended and ordinarily can be evacuated to a pressure of about 60 microns after pumping for a period of 4 to 8 hours. This procedure can be used to control absolute pressures with a differential PPC.

- CAUTION -

DO NOT APPLY MORE THAN 150 PSIG, OR A PRESSURE THAT WHEN ADDED TO THE DIFFERENTIAL PRESSURE WILL CAUSE THE OUTPUT TO EXCEED 150 PSIG WITH RESPECT TO THE "REF" PORT.

1/8 NPT fittings must be screwed into the ports on the PPC rear (unless it was ordered with fittings). Use either Teflon thread sealing tape or Loctite Hydraulic sealant over the threads.

Teflon tape should be wrapped around the thread with 1 to 2 threads exposed on the end. This technique will prevent slivers of the tape from being sliced off as the fitting is tightened and subsequently drawn into the pneumatic system, and possibly into the Transducer. Whenever such a fitting is removed, use tweezers to carefully clean every particle of tape out of the threads before replacing the fitting.

Other types of thread sealants can be used. Mensor has found Loctite Hydraulic Sealant to be suitable for applications from the highest pressures for which a transducer is designed down to the 1 millitorr vacuum region.

NOTE: A thread sealant of some type MUST be used.

Fittings are a major source of leaks. A fitting must be scrupulously clean if being re-used, or replaced if worn. This is especially true of the 37 degree Flare "AN" type of fitting. Even microscopic leaks cause pressure gradients, which can be a source of error in measurement.

3.0 OPERATION

This section outlines the steps needed to put the PPC into operation as a precision pressure measuring or controlling instrument.

3.1 Differential PPC

Switch the PPC function switch to MEASURE and allow the instrument to warm up for a few minutes. The green light on the front panel indicates that the PPC is in the measure mode and the displayed number is the difference between the applied input pressure and the reference pressure.

3.1.1 Zeroing Differential PPC

With the MEASURE and REF ports open to atmosphere, the PPC should indicate approximately zero. If the number is not exactly zero, then the ZERO pot may be adjusted to set the zero. This pot is located behind the instrument front door.

3.1.2 Measuring Differential Pressure

After the PPC has been zeroed, and connected as in Section 2.3.3, apply the pressure to be measured to the MEASURE port. The true pressure will be indicated. See Section 6.1 for the allowable overpressure limits.

3.1.3 Absolute Pressure with a Differential PPC

When it is desirable to measure absolute pressures with the differential PPC, you may want to order a vacuum gauge tube for the reference port. Use caution when setting zero on the differential PPC with vacuum on both ports. With both ports shunted and evacuated, the PPC temporarily reads negative. This is because the reference chamber of the transducer outgasses more than the quartz bourdon helix and therefore has a higher pressure. This outgassing will gradually diminish, and as the two pressures approach each other the instrument will appear to drift upscale after zeroing. Either let the instrument pump for several hours or use a higher pressure (such as 0.1 in. HgA) to establish zero. The more often the PPC is evacuated the faster and lower it will pump down the next time.

> - CAUTION -
>
> DO NOT PLUG THE "REF" PORT ON A DIFFERENTIAL PPC. TRAPPED GAS ON EITHER PORT WILL CAUSE THE PPC TO TRACK TEMPERATURE CHANGES.

3.2 Absolute PPC

When an absolute pressure transducer is installed, only one port is connected at the rear, the MEASURE/CONTROL PRESSURE port. This port is connected to the transducer case.

Switch the PPC to MEASURE and allow the instrument to warm up for a few minutes. The green light on the front indicates that the displayed reading is the actual pressure being measured by the transducer.

3.2.1 Zeroing Absolute PPC

Also see Section 4.7, Vacuum Zeroing Technique.

> - CAUTION -
>
> IN INSTRUMENTS WITH ABSOLUTE PRESSURE SENSORS, DO NOT USE HELIUM OR A HELIUM-CONTAMINATED PRESSURE SUPPLY.

On an absolute PPC the reference pressure is sealed into the quartz Bourdon tube in the transducer at the factory, and is negligible (less than 1.0 millitorr).

The applied pressure must be accurately known or it should be less than the resolution of the PPC.

The recommended method of establishing zero is to evacuate the pressure port with a vacuum pump, to within 10 to 60 millitorr, and monitor the pressure with a thermocouple vacuum gauge. The accuracy of the vacuum gauge in this pressure region is about ± 3 millitorr, which is usually less than the resolution of the PPC.

We recommend that the vacuum gauge tube be installed in the 1/8 NPT pressure port of the transducer. This will assure the most accurate vacuum reading. Because vacuum systems have pressure gradients which vary with outgassing and pump speeds, it is important to measure the pressure as close to the quartz Bourdon tube as possible.

Vacuum gauges and gauge tubes are available as accessories from Mensor.

> - CAUTION -
>
> DO NOT APPLY MORE THAN 50 PSIA TO THE VACUUM GAUGE TUBE. ENERGIZING THE GAUGE TUBE AT PRESSURES ABOVE ATMOSPHERIC SHORTENS TUBE LIFE.

From the pressure indicated on the vacuum gauge, calculate the equivalent reading. Table 3.2.1 may be used to convert millitorrs to inches of mercury absolute (in. HgA) or pounds per square inch absolute (PSIA).

Set the equivalent reading in the display using the ZERO pot on the front of the instrument.

EXAMPLE: Absolute transducer
Range = 0-30 in. HgA
Least significant digit = 0.001 in. HgA
Evacuated to 60 millitorr
From Table 3.2.1, 60 millitorr = 0.00236 in. HgA
Set the display to read 00.002

3.2.2 Measuring Absolute Pressure

Apply the absolute pressure to be measured to the MEASURE port. The true pressure will be indicated on the display. See Section 6.1 for the allowable overpressure limits.

3.3 Control Mode

To generate precisely known output pressures, connect the PPC as in 2.3.3 and switch to CONTROL. The green light from the Measure mode will go off and the red light will come on. This red light indicates that the display is monitoring the setpoint. This setpoint will be the pressure that the PPC will drive to and hold. Turning the SETPOINT ADJUST pots on the front panel will change this setpoint to any point from 1% below zero to 1% above the full span of the PPC.

> - CAUTION -
>
> UPON SWITCHING TO "CONTROL" THE REGULATOR OUTPUT SOLENOID VALVE WILL OPEN. SINCE THE REGULATOR MOTOR RUNS ONLY WHEN THE PPC IS IN THE CONTROL MODE, IT IS PROBABLE THAT THE REGULATOR SETTING IS DIFFERENT FROM THE DESIRED PRESSURE.

At the instant of switching, the pressure will rapidly slew to the regulator setting, and simultaneously the regulator will begin to run toward null. This will not damage the PPC, but it is possible to damage certain types of equipment which may have been connected to the PPC controlled pressure. To prevent the possibility of such damage it is suggested that a

valve be inserted in this output pressure line and be left closed until the PPC output pressure has been stabilized at very close to ambient barometric pressure. Then the valve can be opened.

3.3.1 Setting the Control Setpoint

The control setpoint may be set before switching to CONTROL.

1) Switch to MEASURE

2) Hold the SETPOINT MONITOR switch (located behind the instrument front door) to the left. The red light will come on.

3) Using the front panel SETPOINT ADJUST pots, adjust the display to the desired control pressure setpoint.

4) Release the MONITOR switch and switch the PPC to CONTROL.

The regulator will run to the set pressure and stabilize. After 5 or 6 seconds the green light will come on indicating that the pressure is within .01% of the setpoint. The display will indicate the actual controlled pressure.

The FINE adjust pot may be used to adjust the controlled pressure to the exact pressure desired if needed. As long as the green light is on, the display is indicating the actual measured pressure on the output port.

At any time, the SETPOINT MONITOR switch may be held to the left to display the setpoint. This will not affect the pressure being controlled. Only turning the SETPOINT ADJUST pots will change the output pressure while in CONTROL mode.

3.3.2 CONTROL GAIN and CONTROL DAMP Adjustments

For best control stability and repeatability, and for different volumes connected to the PPC output, the CONTROL GAIN and CONTROL DAMP pots may require adjustment. These pots are located behind the front panel door.

With no output volume on the PPC, the gain and damping may have to be reduced for best pressure stability (no hunting or oscillation).

To minimize the overshoot of a setpoint when changing from one pressure to another, the damping may have to be increased, and the gain reduced.

In general, it's best to have the gain as high as practical for stability and the damping as high as practical for the gain setting.

3.3.3 Regulator Limit Switches

The regulator is equipped with a high and a low limit switch. These switches prevent damage to the regulator in case improper PPC operation causes the regulator to attempt to exceed its mechanical limit.

Some of the conditions which will cause this to happen are:

1) Blocked EXHAUST port: In this case the regulator will run to and repeatedly trip the low limit. All regulator passages and PPC ports except the REF port will rise to the PRESSURE SUPPLY pressure.

2) Called for pressure is lower than the EXHAUST port pressure: The regulator will run to and repeatedly trip the low limit. Output pressure will be approximately the same as the EXHAUST port pressure.

3) Called for pressure is greater than the pressure supplied to the SOURCE PRESSURE port: The regulator will run to and repeatedly trip the high limit. The output pressure will be approximately the same as the pressure at the SOURCE PRESSURE port.

The limit switch will repeatedly trip and reset as long as the improper condition prevails. No damage will be done to the PPC as a result.

On high pressure regulators (above 100 PSI) the regulator will repeatedly run against the upper or lower limit switch until the pressure rises or drops to the new setpoint pressure. As the regulator comes into the control range, it will cycle away from the limit switch and stabilize. This is normal. If it does not stabilize within two minutes, look for a problem. (The gain or damping may need adjustment.)

3.4 Correcting for Head Pressure

Head pressure correction is a calculated correction that is applied to the pressure at the output of the pressure standard in order to correct for the weight of the column of gas or liquid between the standard and the instrument being calibrated. With this correction applied, the "true" pressure at the input port of the instrument being calibrated is known (see Figure 3.4).

3.4.1 Equation for Head Pressure Correction

The general equation for gas head pressure correction is:

$$P2 = P1(1 + \alpha h)$$

where: P1 = Pressure at the output of the pressure standard. (Absolute or Differential.)

P2 = Actual true pressure at the transducer. (Absolute or Differential and same pressure units as P1.)

α = Gas density ratio at 23°C (see Table 3.4.1).

h = Inches difference in elevation between the pressure port on the standard and the pressure port, or reference level, on the transducer under test. (h is negative (-) if the standard is lower than the transducer.)

3.4.2 Head Correction Examples:

Given: A 100 PSID transducer with 10,000 count readout. The transducer port is 24 inches below the PPC pressure port. Air is being used for calibration.

Find: The true pressure at the transducer for 50 PSI and 100 PSI at the PPC.

P2 = P1 [1 + (.0000029315) (24)]

at 50 P2 = 50 [1.0000703561] = 50.00352 PSI

at 100 P2 = 100 [1.0000703561] = 100.007036 PSI

Since the transducer displays 10,000 counts, the instrument should be adjusted to indicate 100.01 at full scale with 100.000 psi at the PPC.

NOTE OF INTEREST: For any pressure range due to gas head pressure:

Maximum % Full Scale Error = $\alpha(h) \times (100)$

α = gas constant from Table 3.4.1

h = pressure port to pressure port height differential in inches

(The actual pressure range does not enter into the equation.)

4.0 CALIBRATION

The Precision Pressure Controller (PPC) is extremely accurate and stable. The instrument should maintain its accuracy for longer than the 90-day period specified, however, it is advisable to verify the calibration periodically. When doing so, follow all procedures carefully and observe all precautions. The PPC transducer must be calibrated in the MEASURE mode. See Section 5.5.1 for adjustments of the PPC Control board after calibrating the transducer.

4.1 Calibration Verification

Mensor Corporation recommends that a performance history log be established and maintained. Factory performance test data should be the first entry in the log. In order to have a locally available test performance for comparison, it is suggested that the instrument be tested against a pressure standard before it is put in service and the test results be recorded at that time. The instrument should be checked thereafter at least every three months until a confidence level is established, and the time between checks can be extended.

4.2 Equipment Required to Calibrate a PPC

4.2.1 The following are needed to calibrate a PPC:

1) Pressure standard (primary or secondary).

2) Dry nitrogen or air (usually bottled gases are used, but instrument air may be used if it is well filtered).

3) Pressure control devices: (valves, variable volumes and automatic pressure controllers).

4) If it is necessary to calibrate the output voltage, a digital voltmeter (DVM) with a 5-digit resolution and an accuracy of 0.01% of full scale or better is required.

The connection of these items is shown in Figure 4.2(A) for differential PPC and 4.2(B) for absolute PPC.

4.2.2 The recommended pressure standards are listed below:

For absolute and differential pressures up to 30 PSI:	
PRIMARY STANDARD	SECONDARY STANDARD
Capacitance mercury manometer Micrometer mercury manometer Air dead-weight tester	*Quartz Manometer or Quartz Manometer/Controller

For gauge pressures up to 500 PSI	
PRIMARY STANDARD	SECONDARY STANDARD
Air dead-weight tester	*Quartz Manometer or Quartz Manometer/Controller

*Quartz Manometer and Quartz Manometer/Controller are registered trademarks of Mensor Corporation.

4.3 Calibration Adjustments

4.3.1 Transducer

The basic instrument zero and span adjustments are accessible behind the instrument front door. Routine calibration of the PPC can be accomplished with these controls, as described later.

Other transducer signal conditioning controls are shown in Figure 4.3.1. The zero and span temperature compensation pots (R32 and R33) are factory set and must not be disturbed without consultation with Mensor Corporation.

4.3.2 Digital Panel Meter (DPM)

Under normal circumstances it is not necessary to calibrate the DPM to obtain the accuracy specified for the PPC. The ONLY time it is necessary to calibrate the DPM is when the accuracy of the analog output voltage is important. If it is deemed necessary to calibrate the DPM, this must be done before calibrating the PPC because it will affect the total instrument accuracy.

To gain access to the DPM controls, first remove the cover, then detach the DPM bracket from the chassis base. Tilt the DPM face upward and locate the controls as shown in Figure 4.3.2.

4.4 Differential and Gauge Pressure Calibration

Connect the PPC to a calibration set-up as shown in Figure 4.2(A) and allow it to stabilize at room temperature for a minimum of one hour.

Calibrate the DPM if necessary, as outlined in Section 4.6.

Vent the reference and pressure ports to atmosphere, and adjust the front panel ZERO for a display to ±00000.

NOTE: The pressure measured by the PPC is referred to a level 6.44 inches above the surface it is setting on. If the pressure is to be referred to another level, a correction should be applied for maximum accuracy as noted in Section 3.4.

Using a pressure standard, apply a calibrated pressure that is at or near the full span of the instrument. After the display has stabilized for 10-15 seconds, adjust the SPAN pot for a display reading of the applied pressure.

Apply calibrated pressure in increments of approximately 10% from zero to full scale. Record the PPC readings and also the analog output voltages, if used.

NOTE: The linearity of the PPC has been corrected and set at the factory and should not change as long as the instrument has not been damaged or modified. Consult Mensor Corporation if it becomes necessary to change the PPC linearity.

4.5 Absolute Pressure Calibration

Connect the PPC to a calibration set-up as shown in Figure 4.2(B) and allow it to stabilize at room temperature for a minimum of one hour.

Calibrate the DPM as outlined in Section 4.6, if necessary.

Connect a vacuum gauge tube to one of the two rear pressure ports of the PPC and, using a good vacuum pump, evacuate the transducer and set the PPC ZERO as outlined in Section 3.2.1, Zeroing Absolute PPC.

NOTE: The pressure measured by the PPC is referred to a level 6.44 inches above the surface it is setting on (center of MEASURE port). If the pressure is to be referred to another level, a correction should be applied for maximum accuracy as noted in Section 3.4.

Using a pressure standard, apply a calibrated full span pressure to the transducer and adjust the SPAN pot for the correct display reading.

Apply calibrated pressure in increments of approximately 10% from zero to full scale. Record the PPC readings and the analog output voltages, if used.

NOTE: The linearity of the PPC has been corrected and set at the factory and should not change as long as the instrument has not been damaged or modified. Consult Mensor Corporation if it becomes necessary to change the PPC linearity.

4.6 Digital Panel Meter (DPM) calibration

The following procedure is used to calibrate the DPM so that the digital readout is proportional to the actual analog voltage of the transducer.

NOTE: Do not attempt to calibrate the DPM unless an accurate voltmeter is available. See Section 4.2.1(4).

Connect the PPC to a calibration set-up as shown in Figure 4.2(A) or 4.2(B) and allow it to stabilize at room temperature for a minimum of one hour.

Locate the DPM adjustments per Section 4.3.2 and Figure 4.3.2.

Connect the digital voltmeter to the analog output of the instrument (Pins 22 and 23 on the rear connector, or TP1 and TP2 on the PPC control board).

With zero differential pressure applied to the transducer, connect a jumper wire between the analog output leads.

NOTE: On absolute instruments, a vacuum pump should be used to evacuate the PRESSURE port.

The DPM should display 00000. If not, adjust the DPM zero pot on the front of the DPM for a reading of ± 00000.

Remove the jumper. If the test voltmeter and the DPM indicate any number other than 00000, adjust the front panel ZERO potentiometer for ± 00000. (See Section 3.2.1 for proper setting of zero for absolute transducers.)

Using a pressure standard, apply a calibrated full span or near full span pressure to the transducer and adjust the SPAN pot for the correct analog voltage output. The correct analog output is calculated with the following equation:

$$\text{Analog Output} = \left(\frac{\text{Calibrated pressure applied}}{\text{Instrument Span}} \right) \times 5$$

EXAMPLE: 40 in.Hg span

Calibrated pressure = 39.900

$$\text{Analog Output} = \left(\frac{39.9}{40} \right) 5 = 4.9875 \text{ volts}$$

Since the DPM is scaled in pressure units it should read 39.900. Adjust the DPM FULL SCALE pot (see Figure 4.3.2) for the correct indication.

NOTE: On an instrument with a span less than 5 psi, the analog output of the transducer will be scaled to the display directly.

For example:

Instrument span.....2000 mm of H2O
Analog output.....2.0000 volts
Display.....2000.0 mm H2O

4.7 Vacuum Zeroing Technique

The pressures of concern in zeroing an absolute pressure PPC are in the 1 to 100 millitorr range. (1 millitorr is .00003937 inches HgA at standard gravity and temperature conditions.)

Surfaces exposed to such pressures will begin to give up their contaminants; liquids such as water, solvents or oils, and gases such as those of air. In order to attain high vacuum the pumping line must conduct to the pump both the gas in the space at the start and the molecules which boil off (de-absorb) the inside surfaces. This is a process of progressive distillation of the contaminants: as the pressure gradually decreases, first one and then another constituant will begin to boil off. The streaming of the particles to the pump constitutes a volumetric gas flow, and thus produces a pressure gradient. This gradient has its lowest pressure at the pump and the highest pressure at the point in the system which is most remote and/or hottest and has the most contaminant.

The discussion thus far assumes the system has no actual (real) leaks in it, but only the "virtual" leaks mentioned.

A leak in a vacuum system is particularly troublesome, since a very small leak from atmospheric pressure converts to a very large volume of gas at the low pressure of the vacuum

system. In flowing to the vacuum source (pump) a significant pressure gradient will be developed. This type of leak, moreover, will usually produce a stable pressure gradient, thus giving the appearance of a well-pumped system. If there is a leak, the result is incorrect vacuum measurement at points in the system other than that of the vacuum gauge.

The transducer will ordinarily be the point of highest pressure as mentioned above. The transducer will measure pressure accurately at high vacuum to the limit of the PPC resolution. For an absolute pressure transducer the pressure to be measured is in the chamber outside of the quartz Bourdon tube, and it is this pressure that must be known in order to set zero. The closer to this chamber the vacuum gauge is connected, the truer will be its reading. The absolute transducer has a plugged 1/8 NPT port into this chamber on its cap which is designed for a thermocouple vacuum gauge tube. The next best choice is to mount the thermocouple on the rear of the instrument.

A word about thermocouple gauges is in order here. At a reading of 10 millitorr, the accuracy of a TC gauge is about $\pm$ 1.6 millitorr . If this $\pm$ 1.6 millitorr is converted into an equivalent angle of the meter pointer, then this same pointer angle error band will approximately track over the meter scale. Thus at a reading of 500 millitorr the error band will be -80, +150 millitorr. Mensor has found that attempts to calibrate thermocouple gauge meters by use of vacuum standards such as McLeod gauge, results only in error unless

the most elaborate set-up is used. It is much more economical to use a type of thermocouple gauge which has interchangeable gauge tubes and then to calibrate the gauge by use of a sealed reference gauge tube at 10 millitorr. This is the recommended method.

A system will pump out faster if its temperature is raised. Introduction of stray contaminants into the system, especially water vapor, will prolong the time required for pump-down. Therefore, the best technique is to pump the unit while it is on and warm, and to allow it to fill to atmospheric pressure from a source of dry nitrogen. One method to shorten pump-down time is to pump to about 50 millitorr and then vent to dry nitrogen, re-pump, re-vent, two or three times. Each time a lower pressure can be obtained. The nitrogen ventings actually flush contaminants off the walls. This is also another reason to use dry nitrogen whenever possible as the calibrating gas.

Pumping time can be minimized by using short, straight, large diameter lines.

5.0 MAINTENANCE AND REPAIR

Refer to Figure 5.1, PPC Block Diagram, and Figure 2.2(B), Layout.

5.1 Electrical Circuits

An understanding of the general wiring of the PPC will aid in locating trouble. There are several categories of circuits in the PPC. The interconnection between modules is shown on wiring diagram RF 12285.

5.1.1 Line Power

Inside the instrument line power is always carried by black and white wires. The line cord connects directly to the two fuses and to the power (function) switch. From there the power is applied to terminal board two (TB2) only in MEASURE and CONTROL positions. When the switch is OFF all power lines, except those from the switch to the fuses, are disconnected.

5.1.2 12.6 VAC

12.6 VAC is supplied by transformer T1 to the regulator limit switch circuits to provide the necessary reversing drive of the limit switch circuit (see schematics RF 10197, RF 10673, RF 12285).

Note that in order to provide this last function, the 12.6 VAC secondary is connected to the plus 9 VDC amplifier power supply. Thus any other circuits that may be connected to this winding are elevated 9 VDC with respect to chassis ground.

5.1.3 Motor Drive Circuit

The amplifier output transistors drive the regulator assembly motor with the function switch on CONTROL (see schematic RF 10673 and RF 10197). The control winding of the motor has its center tap permanently connected to the plus 9 VDC supply of the servo amplifier. With the switch on MEASURE, the power output transistors of the amplifier are disconnected from this voltage.

The regulator drive motor always remains subject to control by its limit switches.

5.1.4 Tachometer Signal

The regulator assembly has a rate feedback tachometer. The signal is generated with respect to ground. The polarity and magnitude depend upon the direction and speed of the drive motor. The maximum output voltage of the tachometer generator is about 1.9 volts.

5.1.5 Signal Circuits

The signal that comes from the pressure transducer is 0 to 5 VDC that is proportional to the pressure. This signal is compared with the setpoint signal (0 to 5 VDC) that comes from the front panel SETPOINT ADJUST pots.

The comparison is done on the PPC controller board and results in an error signal (difference) that is applied to the CONTROL GAIN pot and then to the servo amplifier.

The amplifier drives the pressure regulator. The output of the regulator goes to the transducer, as well as to the MEASURE/CONTROL port. The transducer output signal is thus changed in the appropriate direction to reduce the difference (error) between this signal and the setpoint signal. Ideally, the error will be reduced to zero so that the controlled pressure is exactly the same as the commanded (setpoint) pressure.

5.1.6 Signal Ground

Green is reserved for signal ground. All signal grounds are run to a ground bus on the pot mounting board, on the front panel. This bus is then connected, along with the power cord ground wire, to a single point at the chassis rear.

5.2 Electrical Hardware

5.2.1 Connectors

The connectors are insertable contact type. A problem may occur whenever a voltmeter probe is jammed into the board end of the connector. This can flatten a contact so that it will not work. Look into the board end and see that all contacts line up evenly. A mashed contact can sometimes be straightened with a probe. If it can't, it will have to be removed and straightened. Use AMP tool #693597-1 to remove the contact. Note that the pin numbers are molded into the connector on the wire end.

5.2.2 Servo Adjustments Pots

If the GAIN or DAMP pots give trouble, they may be removed and replaced. Drop the front panel and remove the screws holding the green pot-mounting terminal board from the inside. One pot tab is held by a pop rivet. Drill this out with a #30 drill. Unsolder and replace the pot. A replacement pop rivet may be used or this pot tab may be held in place by a #4 screw and nut.

5.3 Access

5.3.1 Front Panel

The front panel may be un-screwed and swung down in order to work on its wiring, components, or on the display meter. Fold a shop cloth and lay it over the opened door. Remove the panel mounting screws and swing its top forward until the plastic window rests on the shop towel.

The set screws used in Mensor products are either #4-40, 6-spline Bristol or #6-32, 6-spline Bristol. The proper wrenches are available from Mensor.

5.3.2 Module Removal

The six removable modules of the PPC are the servo amplifier, the regulator assembly, the pressure transducer, the power supply, the digital panel meter, and the PPC controller board. All are held in by screws through the bottom plate, except the controller board which is mounted to the back side of the front panel. With the removal of its retaining bolt, the meter slides forward out of the card guides and frame.

5.3.3 Regulator Removal

To remove the regulator the plumbing must first be disconnected. Remove the line from the EXHAUST port to the

regulator, the one running from the REF port to a tee on the right end of the regulator and the one from this tee to the transducer, and disconnect the top end of the tubing from the output solenoid valve to the tee at the left corner of the regulator. To remove the tubing from the input pressure solenoid to the regulator, the rear panel must be swung out of the way. Remove the screws holding the manifold blocks to the rear panel and let these blocks remain suspended by the plumbing. Remove the screws which secure the rear panel to the base plate, except the one nearest the right side (the power cord side). Loosen this last screw and swing the rear panel back. Now remove the last pressure line to the regulator. Remove the four screws holding the regulator to the base plate, unplug the two connectors from the regulator terminal board and lift the regulator out of the chassis.

5.4 Solenoid Valves

The PPC has two solenoid valves, one to shut off the supply pressure to the regulator when the power is off, and one to isolate the regulator from the MEASURE/CONTROL PRESSURE port in the MEASURE and CONTROL mode. Both of these valves have a low wattage, rectified-current coil.

NOTE: The high pressure regulator (above 100 psi) does not have an input solenoid valve. The functional difference between low pressure and high pressure PPC's can be seen by referring to Figures 5.4(A) and 5.4(B).

If a valve simply will not operate, a diode or the coil may have opened. Either the diode or the coil may be replaced.

A leaky valve may be disassembled and cleaned. The procedure for removing a valve is similar to those given in section 5.3.3 for regulator removal. Remove the valve and then the nut which holds the coil cover on. Slide the coil off and note the order in which the parts are assembled. Unscrew the stem from the valve base and clean the seats. When the valve is reassembled, be careful that the o-ring seals go into place properly, particularly the one which seals the top fitting on the outside of the valve. This particular seal can be easily pinched upon reassembly.

5.5 PPC Controller Board

The PPC controller board is mounted on the back side of the front panel. All of the adjustment pots are located along the top edge of the board. See Figure 5.5(A) for the location of the pots and test points.

There are four main functions of this board. (See Figure 5.1, and Figure 5.5(B) and schematic RF 12280.)

1) A stable reference voltage of 6.95 VDC is provided by Z5 for the pressure setpoint adjustment.

2) A voltage comparator circuit, Z3, is also provided to produce an error signal at TP5 that is proportional to the difference between the setpoint voltage and the voltage out of the pressure transducer. This error voltage is used to drive the pressure regulator to the proper pressure output, thus reducing the error to zero.

3) A "pressure stable" circuit, made up of Z1, and Q1 through Q6, is provided. This circuit senses when the control pressure has stabilized at the desired setpoint, and it causes the relay, K1, to switch the display from the reference setpoint to the output of the transducer, thus indicating the actual pressure being controlled.

4) A "data ready" signal is available to indicate when the display is reading actual pressure and not just the desired setpoint. If the optional BCD output is provided, this signal is used to determine when a valid BCD signal is present on the connector.

5.5.1 PPC Controller Board Adjustments

The following checks will insure the proper setting for all of the pots on the PPC controller board. See Figure 5.5(A) for the location of these pots and test points. The controller board schematic is RF 12280.

5.5.1 continued...

Connect the Digital Voltmeter (DVM) common probe to TP1 for the following checks. All voltages are DC.

1) Z2 Zero

a) Remove the blue jumper plug (P5). Connect a clip lead from P5 pin 1 to TP1.

b) Switch the PPC to MEASURE and adjust Z2 zero pot (R45) for 0.0000 volts at TP7. The Digital Panel Meter (DPM) should also indicate zero.

c) Remove the clip lead and replace the blue jumper connector.

2) Setpoint Voltage Calibration

a) Connect the DVM probe to TP7.

b) Switch the PPC to MEASURE. Set both SETPOINT ADJUST pots fully clockwise. The voltage should be +5.050 $\pm$ .003 volts. If it is not, then remove the blue connector (P5) and check for 6.70 to 7.20 volts at pin 4 of P5. If this is correct, reinstall the blue connector (P5) and remove one or both resistors that are across the FINE adjust pot, pins 1 and 2 (CW and CCW). Connect a resistor substitution box (R-box) across these pins. Adjust the R-box for +5.050 volts.

c) Select a 1% metal film 1/4w resistor that is equal to or greater than the R-box value. Solder this resistor across the FINE ADJUST pot "CW" to "CCW" terminals.

d) Recheck the voltage at TP7. It should be 5.047 to 5.053. If it is greater than 5.053, then use the R-box to select a pad resistor value and solder a resistor of this value across the pot. The final voltage at TP7 should be 5.05 ± .003 volts.

e) Adjust both SETPOINT ADJUST pots fully counter-clockwise. The DVM should indicate -0.05 ± .003 volt at TP7.

f) Reselect the pad resistor if needed to meet both the specification called for in step d as well as step e.

3) Z3 Adjustments

a) Use the SETPOINT ADJUST pots to set the voltage at TP7 to 0.0000.

b) Unplug the power connector (P13) from the transducer and connect a clip lead from TP2 to TP7. Connect the DVM to TP5.

c) Adjust Z3 zero pot (R31) for 0.0000 volts.

d) Turn the SETPOINT ADJUST pots fully clockwise, and adjust Z3 balance pot (R46) for 0.0000 volts.

4) Z1 Zero and Gain

a) With TP5 at zero volts, connect the DVM to TP4. Adjust Z1 zero pot (R5) for zero ± .0200 volt. (The gain of this op-amp is about 1400, so the output at TP4 will be somewhat noisy.)

b) Remove the clip lead from TP7 and connect it to TP1. (This will ground TP2.) Move the DVM + lead to TP5.

c) With the SETPOINT ADJUST pots, adjust the voltage at TP5 to +.0010 volts.

d) Move the DVM + lead to TP4. Adjust Z1 gain pot (R2) for −1.4 ± .1 volts.

e) If Z1 gain pot (R2) is changed, the Z1 zero should be reset. Repeat steps a through d if needed.

5) Pressure Stable Delay

a) Turn the SETPOINT ADJUST pots counter-clockwise. Connect a second clip lead from TP4 to TP1. (TP2 should still be connected to TP1.)

b) Unplug the regulator assembly Servo Motor, and switch the PPC to CONTROL. The green LED should stay on.

c) Disconnect the clip lead at TP4. The red LED should come on. Reconnect the clip to TP4 while noting the time it takes for the green LED to come on after the clip is connected to TP4. This should take 5 seconds ($\pm$1). Adjust the delay pot (R11), if needed, to set this time. (A delay time of 2 to 15 seconds may be selected if desired.)

d) Set the COARSE adjust pot one turn clockwise, and repeat step c. The delay should be the same as the first time within 1 second.

e) Reconnect the clip lead to TP4. The green LED should come on. Switch the momentary SETPOINT MONITOR switch to the left. The red LED should come on for as long as this switch is held on.

f) Switch the PPC to MEASURE and remove the clip leads. Connect the DVM to TP5. Connect the transducer power connector. Connect the regulator motor.

g) Set the control GAIN and DAMP pots to mid-range (or normal setting, if known).

6) Control Check

a) Connect a source pressure supply to the PPC, 5 to 10% greater than the transducer span. Cap off the output port of the PPC. If the PPC is an absolute unit with a span less than 15 psi, connect a vacuum pump to the EXHAUST port.

b) Set the COARSE pot fully clockwise. Push the SETPOINT MONITOR switch and hold it. (The red LED should be on.) With the FINE pot, adjust the PPC reading to full scale. (The COARSE pot may have to be re-adjusted.)

c) Release the SETPOINT MONITOR switch and switch the PPC to CONTROL. The red LED should come on and the regulator should drive to the setpoint.

d) The regulator should stabilize at the setpoint and after about 5 seconds the green LED should come on. The PPC should display the set pressure.

e) The DVM should indicate an error of less than $\pm$ .0002 volt at TP5. Adjust the control gain and damping as needed for best stability and minimum error voltage.

f) If the error remains generally greater than $\pm$ .0002V, then the servo amplifier may have a D.C. chopper transistor offset or leakage on the PC board near the

choppers. An offset of ± .0002 volt at TP5 represents an error of only ± .002% of span between the setpoint pressure and the actual controlled pressure. This is one minor digit out of 50,000 counts. The error between the setpoint and actual controlled pressure may be compensated for by adjusting Z3 zero pot (R31) until the setpoint reading agrees with the final controlled pressure reading.

g) Use the COARSE pot to reduce the pressure setting a few percent (approximately 1/3 turn counter-clockwise). The red LED should come on and the regulator should drive to the new setting. The green LED should come on after a few seconds.

5.6 Servo Amplifier (See Schematic D 10673)

5.6.1 Construction

As the schematic shows, the amplifier has 3 sections, chassis assembly, preamplifier and power supply board. Two screws hold each board to the chassis. Remove the screws of either board to lay the amplifier open for access to both boards. Test points and selected component terminals are always on the circuit side of the board where they will be obvious.

The power output transistors are mounted on the side of the amplifier chassis. When replacing a power transistor, be sure

that the collector (center lead and mounting tab) is not shorted to the chassis.

5.6.2 Circuits

1) Power Output Circuits

The most frequent source of amplifier trouble is the output power transistors. These are directly connected to the power output board. The output transistor collectors are supplied through their load, the center-tapped motor winding. If the motor appears to have lost torque first check to see that both collectors are 9 VDC above ground. If not, check the wiring, switches and connectors to find the break. Typically, the problem will not be on the board, but in the transistors or the wiring.

If the motor is completely dead, it could be that power is not getting to the motor center-tap. In this case there will be 9 VDC on pin 3 of the amplifier output connector, but not on the collectors.

If the motor has inadequate torque or is audibly noisy one of the output transistors may have a partial short. Check the voltage on R15 and R16. These are the power transistor emitter resistors. High voltage (.5 to 1.5 volts) here will indicate that the associated transistor is shorted. Continued operation in this condition may cause the board beneath the offending resistor to become scorched.

This can cause a bad appearance without affecting circuit performance. Replace the bad transistor only.

The rest of the circuit on the board is rather straightforward and gives little or no problem. Q1 and Q2 form a phase splitter, with the input signal being developed across the collector load resistor R1, of the output transistor on the pre-amp board. Q3 and Q4 are push-pull driver stages for the power output transistors Q5 and Q6.

2) Pre-Amplifier Board

This board contains a solid-state chopper, AC signal amplifier, and the 17 volt regulated power supplies for all the preceeding functions.

The chopper is a single-ended, grounded, series-shunt FET circuit. It is driven by a square wave signal excited by line frequency. The only record of a problem has been accidental shorting of a chopper transistor Q1 or Q2. An oscilloscope is required to troubleshoot this condition. With a square wave drive signal present on each gate (terminal G) and a DC millivolt signal in on input connector pin 2, an AC square wave signal equal in size to the DC input should be observed on C5 to ground. If not, replace either Q1 or Q2, whichever cures the problem.

The op-amp Z1 forms a circuit with a voltage gain of 131. Q3 primarily is to provide isolation between Z1 (which generates a signal with respect to ground) and the Q1-Q2 stage of the Power Amp Board (which is referenced to the 17 V line). This section will normally work if the DC voltages shown on the schematic diagram are present. If Z1 is replaced, check the DC voltage on Z1, pin 6. This should be adjusted to less than 0.5 VDC by connecting a resistor of proper value between either E5 and E6, or between E7 and E8, as applicable.

5.7 Regulator Assembly

This assembly is composed of the servo regulator, the servo motor, tachometer generator, the gearing, and the supply and exhaust pressure controllers.

5.7.1 Servo Regulator

The servo regulator has three sections, the top, the exhaust spacer section and the bottom section. The bottom section is mounted directly to the regulator assembly mounting plate. This section should not be de-mounted, nor should its position on the plate be shifted, nor should its contents or external gearing be disassembled. Reassembly and adjustment involves a proprietary technique. (See Section 5.3.3 for information on removing the regulator from the chassis.)

The only need for removing the top section would be in the event of contaminated internal valve seats due to continuous use of oily or otherwise contaminated supply gas. If removal is deemed necessary proceed with caution.The diaphragms usually cause the regulator sections to stick together and damage can result when separating these sections.

Remove the regulator top section as follows: Temporarily plug in the regulator. Set the PPC on CONTROL and select a setpoint which causes the regulator to run to its low limit switch. Switch the instrument OFF and unplug the regulator. Remove the necessary plumbing running to the regulator top. Remove the four screws in the top. Carefully separate the top section from the exhaust section. It is best to leave the rest of the regulator intact. The two valve seats, one in the middle of the diaphragm section and one in the top section may be unscrewed and cleaned. Use any ordinary cleaning solution. Note that the plastic seat is Delrin (acetal resin); do not use a solvent which will attack it.

Proper orientation of the regulator sections and the diaphragms must be maintained during re-assembly, or an internal passage will be blocked.

5.7.2 Upstream and Downstream Controllers

The two grey painted devices on the left of the servo regulator are the controllers. The techniques used in adjusting them for optimum performance is beyond the scope of this discussion. Therefore, do not open the controllers.

5.7.3 Regulator Drive Train

There are two sections to the drive train: the plastic chain and sprockets and the precision gear set. Do not attempt to adjust the gear mesh. Cleaning and re-lubricating the gears is rarely needed, but if it must be done, clean the gear teeth with a brush and a solvent such as chlorothene. A paper towel beneath the gear helps to soak up the excess. Re-lubricate with Lubriplate 630-AA. Also clean and lubricate the friction surfaces of the limit switch actuator discs with the same grease. If a motor or tachometer generator must be removed and replaced, then the plastic chain will have to be adjusted. Both the motor and the tachometer generator mounting positions should be shifted to provide just enough chain tension to remove slack but not enough to cause sprocket cogging and/or binding. Both sprockets of a set must be fixed on their shafts so as to run in the same plane.

After long use the drive chain will dry out and become creaky. To remedy this apply a light weight oil (such as vacuum pump oil) on its entire length and then blot off the excess.

5.7.4 Servo Motor

The motor does not ordinarily cause problems. Occasionally a motor will develop gear noise. This can be detected by removing the drive chain and allowing the motor to run free. Replacement motors are available from Mensor Corporation.

5.7.5 Tachometer-Generator

Some tachometer-generators have developed a progressive partial short in the commutator. This was the result of using a faulty bearing lubricant, a one time error at the vendor's plant. The effect of this condition is a gradual loss of damping, seen as a recurring requirement, over a period of time, to increase the CONTROL DAMP pot setting. To check for this, measure the resistance across the tachometer-generator terminals with the instrument in STANDBY. This should be 12 to 15 ohms. Shorted tachometers have read as low as 2 to 5 ohms. If such a condition is found, the tachometer-generator must be replaced. Unsnap the drive chain and remove the drive assembly to do this. Be sure to connect the green tachometer wire to the tachometer (+) terminal.

5.7.6 Limit Switches

Limit switches are subject to mechanical failure, and should be replaced as soon as such a failure is discovered. To run a regulator with a defective limit switch is to risk permanent damage.

Replacement is obvious. The limit is set by positioning the switch and forming the blade.

To set the low limit, disconnect the chain which drives the pinion shaft. Manually turn the large gear clockwise (viewed from the regulator bottom) until the end of travel is just reached. Do this gently; do not allow the gear to jam at the end of travel. Now back off one full turn and position the switch to just trip at this point.

To set the high limit switch the regulator must be put into operation temporarily, controlling at about 106% of the instrument span. Disconnect and remove the regulator assembly, leaving the regulator drive shaft as it was at 106%. Set the high limit switch to trip at 1/2 turn counter-clockwise past this point.

On a high pressure regulator, the limit switches are set to operate when the larger gear has turned 120° to 180° beyond either null position.

5.8 Pressure Transducer

The transducer consists of a frame assembly in a pressure tight case and a signal conditioning circuit board. Figure 5.8 is a block diagram of the pressure transducer.

5.8.1 Transducer Frame Assembly

The frame assembly is a pressure sensing force-balanced device housed in a pressure tight case. In differential pressure models, the reference pressure surrounds the force-balanced system inside this case. The pressure to be measured is applied into a fused quartz Bourdon tube which applies a force (Fp) to a balance arm. This force is directly proportional to the differential pressure between the inside and outside of the Bourdon tube. (See Figure 5.8.)

In absolute pressure models, the Bourdon tube is permanently evacuated and sealed to provide an absolute reference. The pressure to be measured is then applied into the case around the outside of the Bourdon tube and thus the forces (Fp) and (Fm) are applied in the reverse direction on the balance arm.

When the pressure changes, the balance arm moves slightly from its center position: This movement is detected by sense coils and an AC signal is generated. The phase of this signal indicates the direction of movement.

The AC signal is processed by the signal conditioning circuit board which develops a DC current which in turn is applied to the torque motor. This produces a force (Fm) on the balance arm that returns the arm to its center position and nulls the sense coil output. A change in force produced by the Bourdon is balanced by a proportional change in current in the motor.

5.8.2 Signal Conditioning Circuit Board (SCCB)

The SCCB contains all the electronic circuits needed to produce a linear analog output voltage which is proportional to the pressure in the Bourdon tube. The SCCB provides as standard 0 to 5 VDC output for any Bourdon range above 5 PSI, and one volt per 10,000 counts of display below 5 PSI. The basic circuits are shown in Figure 5.8.

The SCCB is mounted to the outside of the transducer case and is connected electrically to the balance system through an 8-pin high pressure feedthru connector. The following descriptions apply to the various circuits contained on the SCCB:

1) Power Supply Inverter

This section of the SCCB provides isolation of the external 12 volt power supply as well as providing

regulated ± 8 VDC to the rest of the circuits. The power inverter circuits allow the other SCCB circuits to operate with negligible error over an input supply voltage range of 10 to 15 VDC.

2) Reference Oscillator

This is a free running sine wave oscillator that provides excitation to the sense coils of the frame assembly. It also provides the reference phase for the demodulator.

3) AC Amplifier and Demodulator

The AC amplifier receives the small error signal from the sense coils and boosts it to a level sufficient to be demodulated with little or no error.

The demodulator is a full wave phase sensitive detector that provides a DC signal of the appropriate polarity to the motor amplifier.

4) Coarse Zero Adjustment

This adjustment, pot R72, provides a ± 2% of span coarse adjustment of zero (see Fig. 4.3.1). This circuit changes the balance of the sense coils and is the AC circuit ahead of the AC amplifier. The use of this pot allows the normal front panel zero pot on the PPC to operate over a very

limited range. This provides for better resolution and greater stability of the zero setting.

5) Motor Amplifier

The motor amplifier converts the error signal to a direct current drive to the torque motor. This in turn produces the necessary force to balance the input pressure force.

6) Linearity and Temperature Correction Circuit

NOTE: Temperature and linearity adjustments are set at the factory and should not be changed without consulting Mensor Corporation.

The correction amplifier is part of the linearity and temperature correction circuit. This amplifier converts the torque motor current to an accurate voltage equivalent, provides zero adjustment for the transducer, and adds linearity and temperature compensation to the signal.

7) Output Amplifier

This amplifier provides the span adjustment as well as the necessary output voltage and current drive for the digital panel meter.

5.9 Readout Assembly

The readout assembly is a highly stable digital panel meter (DPM) with a 4-3/4 digit (39999) display. The DPM input is filtered and scaled to allow the meter to display the pressure in units proportional to the 5.0000 volt output of the transducer. Thus the instrument is direct reading in engineering pressure units.

EXAMPLE: If the pressure span is 20 PSI, then the transducer output will be 5 volts for 20 PSI. The DPM input would be divided down from 5 volts to 2 volts full scale, so that it could indicate 20.000 for 20 PSI.

As an option the meter can be modified to display up to 50000 at 5 volts output.

5.9.1 Meter Over-ranging

Standard meters will over-range if more than 3.9999 volts are applied to the input. The DPM will flash all the digits off and on at about four times a second to indicate the over-range condition. The numbers displayed during such flashing will remain accurate up to 10% over full scale.

On meters provided with the 50000 count option the meter will not indicate an over-range. The display will remain accurate up to about 52000 counts (5.2 volts). Beyond that the displayed numbers become unreliable.

The transducer can output no more than ± 8 volts when overpressured which is well below the signal voltage level which can be safely input to the DPM.

5.9.2 Adjustments

There are only three adjustments that may be made to the meter; zero, span, and zero width. The zero and span adjustments are covered in Sections 4.3.2 and 4.6. See Figure 4.3.2 for the location of the adjustments.

1) Zero Width Adjustment

The resolution of the meter is .0001 volt (100 microvolts), that is, one least significant digit equals 100 μv. The zero width, from -1 count to +1 count, should be 100 to 180 μv wide.

If the meter zero width is too narrow, the display may switch from, say, +2 counts to -2 counts when the input voltage to the meter is slowly reduced through zero. The meter will never indicate zero.

If the zero width is too wide, the display may stay on zero even though the input is changed from, say, +.0002 volt through -.0002 volt. The display might then change to -1 count when the input goes to -.0003 volt.

a) To correct for a zero width problem, connect a digital voltmeter (DVM) that has a resolution of 10 microvolts to test points TP1 (common) and TP7. (A good digital voltmeter with a resolution of 100 microvolts may work.)

b) With the PPC in the MEASURE mode, push and hold the SETPOINT MONITOR switch while adjusting the SETPOINT ADJUST pots for ± 00000 volts on the DVM.

c) Adjust the display meter front zero pot so that it is switching from a positive to a negative reading.

d) Slowly change the voltage with the PPC FINE adjust pot from zero to (+)300 μvolts. The display meter should change from zero to +1 count when the voltage is between 50 and 80 μvolts. Do the same in the negative direction.

e) Adjust the zero width pot, located on the right side of the display meter, for the proper change-over point. Clockwise rotation of this pot makes the zero width narrower.

f) If the meter is adjusted properly, the display will indicate 0, +1, +2, +3, etc and 0, -1, -2, -3, etc when the voltage is changed. It should follow one count for each 100 microvolts in each polarity.

5.10 Power Supply

The power supply provides filtered, unregulated 12 volt DC power to the transducer. It can supply enough power for two transducers (300 ma). Figure 5.10 shows the power supply terminal locations.

6.0 SPECIFICATIONS

6.1 Measurement

ACCURACY/STABILITY/LIMITS	
Zero Drift	Warmup drift (after two hours): ±.018% F.S. ± one LSD* Temperature (15 to 35°C): ±.0046% F.S./°C ± 0.2 LSD/°C Time (90 days): ±.038% F.S. ± one LSD Zero may be reset without affecting span or linearity
Span Drift	Temperature (15 to 35°C): ±.0016% F.S./°C ± 0.2 LSD/°C Time (90 days): ±.018% F.S. ± one LSD Span may be reset without affecting zero or linearity
Non Linearity	Over operating temp. range for 90 days: ±.008% F.S. ± one LSD
Hysteresis & Repeatability	±.001% F.S. ± one LSD
Over-Pressure Ratings	Maximum pressure applied to PPC Transducer: Span from 1 to 200 psi: 200% of span Span from 201 to 500 psi: 150% of span
Calibration (Deviation from our primary std. over the range.) Mensor std: ±.02% of reading	±.008% Full Scale ± one LSD after setting zero at operating temp. ±.038% F.S. ± one LSD over operating temperature range for 90 days after setting zero at the operating temp.

*LSD = Least Significant Digit Displayed

Effect of Gravity or Orientation	
Zero	0.03% max. in any orientation May be removed by resetting zero
Span	No effect

Response time for full scale step pressure input Time Constant for 99% Full Scale	
Display and BCD Output	1.5 seconds
Analog	0.1 seconds

Accuracy/Stability	
Set Point Stability	±.005% F.S. ± one LSD
Pressure slew rate (with one liter volume)	Low Pressure Regulator (≤100 psi): 30 seconds F.S. Max. High Pressure Regulator (>100 psi): 60 seconds F.S. Max.
Pressure Stabilization time. Added to slew time.(with one liter vol.)	Low Pressure Regulator (≤100 psi) 15 seconds max. (above 1 PSIA) 30 seconds max. (below 1 PSIA) High Pressure Regulator (>100 psi) 60 seconds max.
Pressure Overshoot	<.5% F.S. with or without 1 liter volume
Stability of controlled Pressure	±.002% F.S. ± one LSD
Controlled Pressure agreement with a Set Point	±.002% F.S. ± one LSD

Adjustments and Limits	
Coarse Pressure Adjustment	10% F.S. per turn (10 turn pot)
Fine Pressure Adjustment	0.1% F.S. per turn (10 turn pot)
Supply Pressure	105 to 120% of F.S. pressure Accurate external regulation is not required.
Exhaust Pressure	21 Liter/Min., 25 millitorr vacuum pump for control of absolute pressures
Reference Pressure	Low Pressure Differential PPC (≤100 psi): Vacuum to 100 psi High Pressure Differential PPC (>100 psi): Vacuum to 500 psi NOTE: ((Measure/Control pressure) - (Reference Pressure) must not exceed overpressure specification.
Min. Controlled Pressure	Exhaust Pressure plus .025 psi or .05 PSIA, whichever is higher

6.3 Physical Properties

(see Figure 7.3)

Width	11.0 inches
Height	8.4 inches
Length	15.4 inches
Mechanical shock	3 g/s max
Weight	28 pounds
Weight (shipping)	40 pounds
Weight (shipping)	45 pounds (with Rack Adapter)

Transducer Volume (cubic centimeters)		
	Pressure side	Reference side
Differential unit	0.4 to 0.6 cc	116 cc
Absolute unit	116 cc	n/a

Ports
All pressure ports are 1/8 NPT

Temperature Ranges		
	Deg. F	Deg. C
Operating	59 to 95	15 to 35
	-22 to 176	-30 to 80

6.4 Materials in Contact with Pressure Media *

	Chamber	
Differential unit Absolute unit	Pressure N/A	Reference Pressure
<u>Metallics</u>		
Aluminum	X	X
Brass	X	X
Cadmium		X
Copper		X
Gold		X
Invar (36)	X	X
Iron		X
Phosphor Bronze		X
Platinum	X	X
Silver		X
Silver Solder	X	X
Solder (60/40)		X
Stainless steel (316)	X	X
<u>Non-metallics</u>		
Buna-N rubber	X	X
Epoxy		X
Fiberglass		X
Loctite sealant	X	X
Mylar		X
Nylon		X
PVC		X
Quartz	X	X
Silicone grease	X	X
Silicone rubber		X
Teflon		X

* Pressure media; clean, dry, non-corrosive gases.

<table>
<tr><td>Analog (output)</td><td colspan="4">Zero to +5 VDC for spans greater than 5 psi (1 milliamp max. load)
1.0 VDC per 10,000 counts on the display for spans less than 5 psi</td></tr>
<tr><td>Analog accuracy</td><td colspan="4">±.04% of reading ± 2 millivolts</td></tr>
<tr><td rowspan="3">(optional) Digital input/ output</td><td></td><td colspan="2">Requirement</td><td>Function</td></tr>
<tr><td></td><td>Low level</td><td>High level</td><td>Input/ Output</td></tr>
<tr><td>Input</td><td>0 to .8V sink .2ma</td><td>+2.0 to +5.0V source .04ma</td><td>Inhibit</td></tr>
<tr><td></td><td>Output</td><td>0 to +4V sink +1.6 ma</td><td>+2.4 to 5.5V source +0.4 ma</td><td>5-digit parallel BCD, polarity, data ready</td></tr>
<tr><td>Connector</td><td colspan="4">24 pin; mating connector is furnished (Amphenol #57-30240)</td></tr>
</table>

6.6 Power

Standard	115 volts AC, ± 10% 50/60 Hz
Line Voltage variation	Less than ± one least significant digit effect for ± 10% voltage variation
Watts	45 VA max
Optional power	230 volts, AC, ± 10% 50/60 Hz

6.7 Mounting

Standard	Table model with handle
Optional	Rack adapter (see Fig. 7.3)

7.0 OPTIONS AND ACCESSORIES

7.1 BCD Output

This option provides a 4 1/2 digit parallel BCD output on the rear 24 pin connector. This output is the same as the display and, depending on the digital panel meter resolution option, is 39999 counts or 55000 counts maximum.

See Table 7.1 for functions and pin numbers. The output is high (5 volts) for true, and is not buffered or isolated. It will drive one TTL load. Wiring Diagram RF 12285 shows the internal BCD connections.

7.1.1 Inhibit Function

Grounding (BCD Common) the INHIBIT contact causes the display, and the parallel BCD output, to maintain its reading regardless of pressure changes at the transducer. A high logic level (or open) on the INHIBIT contact enables the display, and allows BCD output to update. The INHIBIT function is not available when the 50000 count option is installed.

7.1.2 Polarity Function

The POLARITY function goes high when the polarity of the input signal is positive.

7.1.3 Data-Ready Function

The DATA-READY signal on the Precision Pressure Controller goes high to indicate that the pressure is stable and the conversion process is completed. During this time the BCD and POLARITY outputs represent the value of the measurement and are available for use by an external device. The pulse width varies from 20ms at zero, to 120ms at full scale. This time may be extended indefinitely with a low level on the INHIBIT input.

The DATA-READY signal is only present in the MEASURE mode. This is indicated by the front panel green LED being on.

7.2 High Resolution Display (50000 count)

This option modifies the digital panel meter so that its range is extended from 39999 to 50000. It is recommended where greater resolution is needed or when the number 4 or 5 is the first digit of the full scale span. When this option is installed, the digital INHIBIT function is no longer available on the rear connector. Also the overrange "flashing" of the display is not provided.

7.3 Rack Adapter Panel

There are two rack adapter panels available: a 19 inch wide by 10.5 inch high panel with a cutout and shelf for one

instrument, and a 24 inch wide by 10.5 inch high panel with two cutouts and shelves for two instruments. See Figure 7.3 for outline dimensions. See Section 2.3.2 for installation.

7.4 Relief Valves

Relief valves on Mensor products are generally categorized in two ways: (1) the method of mounting and (2) valves rated to crack at or below 155 psi and those rated to crack above 155 psi.

7.4.1 Mounting Styles

Valves are either mounted on the Transducer or on the instrument manifold block(s). Any pressure valve may be mounted on the manifold block.

1) Transducer-Mounted Valves

a) One-way ΔP relief valves are mounted off the transducer fittings within a special aluminum block. Normally the cracking direction is from Pressure to Reference.

b) A two-way ΔP valve is similarly mounted in a special aluminum block. In this case the cracking pressure for each direction is separately specified.

2) Manifold-Mounted Valves

a) A manifold-mounted valve operates independently of transducer-mounted valves. In order to mount these valves the manifold block is drilled and tapped 1/4 NPT.

b) Popoff valves may be any pressure from 1 psig to 1100 psig. They are mounted on the Pressure port side of the block and vent to atmosphere inside the instrument.

7.4.2 Performance

All valves reseat at a pressure slightly below, but very close to the cracking pressure. A valve set to crack at 55 psi, for example, will reseat at about 53 to 54 psi, repeatedly. A seated valve, clean and in good condition will be vacuum tight (in the 10 millitorr absolute pressure region). If a valve does not perform this well, it is probably dirty.

7.4.3 Servicing the Valve

All valves must be removed for cleaning or resetting the cracking pressure. When a valve is put back into place, be very careful that the pipe threads are cleaned. The original installation uses an anaerobic hydraulic sealant which crumbles when the valve is removed.

All such debris must be removed before re-installation of the valve. The same is true if teflon tape is used. If any sealant particles get onto the valve seat, the valve will not completely reseal after being cracked.

1) High Pressure Valves (over 155 psi)

The seat of the high pressure valve is in the body half with the male pipe thread.

To reset pressure unscrew the two halves a partial turn and reach into the female end with a 5/16" Allen wrench. Turn the inner portion clockwise to increase pressure. Then re-tighten the two valves. To disassemble the valve, completely remove the female thread half and then the inner portion. Carefully clean the last piece to come out and its mating seat, part of the first half of the valve. Be careful not to nick or bend this knife-edge seat. Replace the parts and set the pressure.

2) Low Pressure Valves ($\leq$ 155 psi); (see Figure 7.4.3)

On low pressure valves the spring-adjusted screw is reached through the male pipe end, or higher pressure end. It will be noted that the spring is held by a 3-lobed nut which is, in turn, locked by a very small hex nut. The ideal way to manipulate these two nuts is with Circle Seal tools no. 10086 and 10087. If these tools are not

available, needle-nosed pliers for the hex nut and a thin probe for the 3-lobed nut will suffice. Unlock the hex nut and adjust the 3-lobed nut until the cracking pressure is correct, then hold the latter and lock the former.

Ordinarily this valve can be cleaned without dis-assembly. Manually depress the poppet and hold it open while flushing the valve in solvent. Then use clean instrument air to blow it out. Do not use a solvent which will attack Buna-N, which is the seal material.

7.5 DV6M Thermocouple Vacuum Gauge

The thermocouple (TC) gauge tube option consists of a thermocouple vacuum gauge tube which is screwed into a pressure fitting on the transducer. For the differential transducer, the tube is mounted to the reference port, whereas on the absolute transducer the TC gauge tube is mounted to the PRESSURE port.

The TC gauge tube connects to an octal connector which is wired to a connector on the rear panel of the instrument. See Figure 7.5 for the wiring connections.

The TC gauge tube is a Hastings DV6M and may be read out only on a Hastings VT6 readout meter. The DV6M is identified by a yellow base.

7.5.1 Use

With the VT6 vacuum meter on and connected to the DV6M, the meter pointer should read "ATM".

When vacuum is applied to the DV6M, the meter will so indicate. See Section 4.7 of the manual for further instructions.

7.5.2 Maintenance

If the gauge does not work, try the following. Be sure the power has not failed. Check the connections into the readout meter and trace power to the gauge tube socket. Approximately .15 VAC can be measured with a voltmeter between pins 3 and 5, and between pins 5 and 7 on the octal socket.

If the cause of the gauge malfunction is not apparent try a new gauge tube. A defective gauge tube is the most common cause of failure. The circuit can be rapidly checked by plugging in a new tube and observing an "ATM" reading on the indicator, without pneumatic installation into the system. The open end of the tube should point down for this check. This will allow any dust or condensed vapors to drain out.

Gauge tubes may be cleaned by filling carefully with an eyedropper with appropriate solvents. Solvents such as trichloroethylene, Freon 23, acetone, etc., are helpful. Rock gently (do not shake), drain, and repeat. Finish with an alcohol rinse. De-gas with mild baking at about 150°F. and re-install in the vacuum system. System contamination of pump oils and process vapors are the chief source of gauge tube failure.

7.6 Non-Standard Voltage

The "non-standard voltage" option is a modification which allows the unit to accept a line voltage other than 115 VAC.

For this option, the standard transformer (T1) is replaced by the transformer and power circuit shown in Figure 7.6.

Tap #1 is always connected to TB2 terminal 10 (white power wire). The other connections are as follows:

Voltages	TB2-1	TB2-11
280-241	T1-5	T1-2
240-221	T1-5	T1-3
220-195	T1-4	T1-3
120-106	T1-3	T1-3
105-92	T1-2	T1-3

*All other transformer taps are unused and should be insulated.

The proper fuses for the 100 volt and the 200 volt ranges are as follows: (all fuses are slo-blo)

Input Voltage Range	Fuses
90 - 125	1 Amp
> 125	1/2 Amp

NOTE: Ordinarily, whenever this kit is used, the power frequency is 50 Hz. These two requirements are independent. The only effect of changing from 60 Hz. to 50 Hz. will be to slow down the pressure regulator by about 17%.

7.7 Multiple Pressure Units Switch

A standard instrument has one full scale pressure range and displays this range in engineering units such as psi, in.h2o, mm Hg., etc. The standard instrument can be modified to display the full scale pressure range in up to five different engineering units. A multi-position switch is used to select the different readouts. Although the operation of this special instrument is the same as the standard instrument in any particular switch position, the calibration of the multi-readout instrument should be performed as follows:

1. Connect the instrument to a calibration set-up as shown in Figure 4.2(A) or 4.2(B).

2. Remove the instrument cover and locate the DPM full scale adjustment, (see Section 4.3.2 and Figure 4.3.2), and the four unit span adjustments, (Figures 7.7, A and B).

3. Apply zero pressure and adjust the instrument zero, Figure 2.2(A), for +00000 display. Verify that the display is zero for all switch positions, by switching the units switch, located to the right of the display.

4. Select the first (most counter-clockwise) switch position of the units switch.

5. Using the pressure standard, apply a calibrated full scale pressure to the instrument.

6. If an accurate analog output is required, adjust the instrument span, Figure 2.2(A), for the correct voltage output (Pins 22 and 23 on the rear connector, or TP1 and TP2 on the controller board, Figure 5.5(A)). For instruments with spans of 5 psi or greater, the full span output is 5.0000 VDC.

7. Adjust the DPM full scale pot for the correct readout.* Refer to Figure 7.7(A) for the following adjustments.

8. Select the next switch position (one step clockwise) of the units switch.

9. Adjust the number two (2) units pot for the correct readout.*

10. Repeat steps 8 and 9 for each additional switch position, adjusting pots 3, 4 and 5 as appropriate.

*NOTE: The DPM reading can be calculated with the following equation:

$$\text{DPM DISPLAY} = \frac{(\text{Instrument Span}) \times (\text{Analog Output Volts})}{5 \text{ Volts}}$$

The display should indicate the same as the calibrated pressure applied.

If one switch position has been calibrated, subsequent switch positions and their corresponding readouts can be calibrated using the proper coversion factor to the engineering units desired. If this method is used, the first switch position to be calibrated must be the pressure units range which has the highest resolution.

7.8 Remote Pressure Control

The Remote Pressure Control option allows the user to input a control signal via a connector on the rear panel. The control signal should be 0 to 5.1 volts D.C. with a 50 db signal to noise ratio. A front panel mounted switch selects local or remote control.

Refer to Figure 7.8(A) for wiring details of the remote pressure control option. To set zero, adjust pot R45 (Z2 zero). See Figure 7.8(B)

- APPENDIX A -

Figures

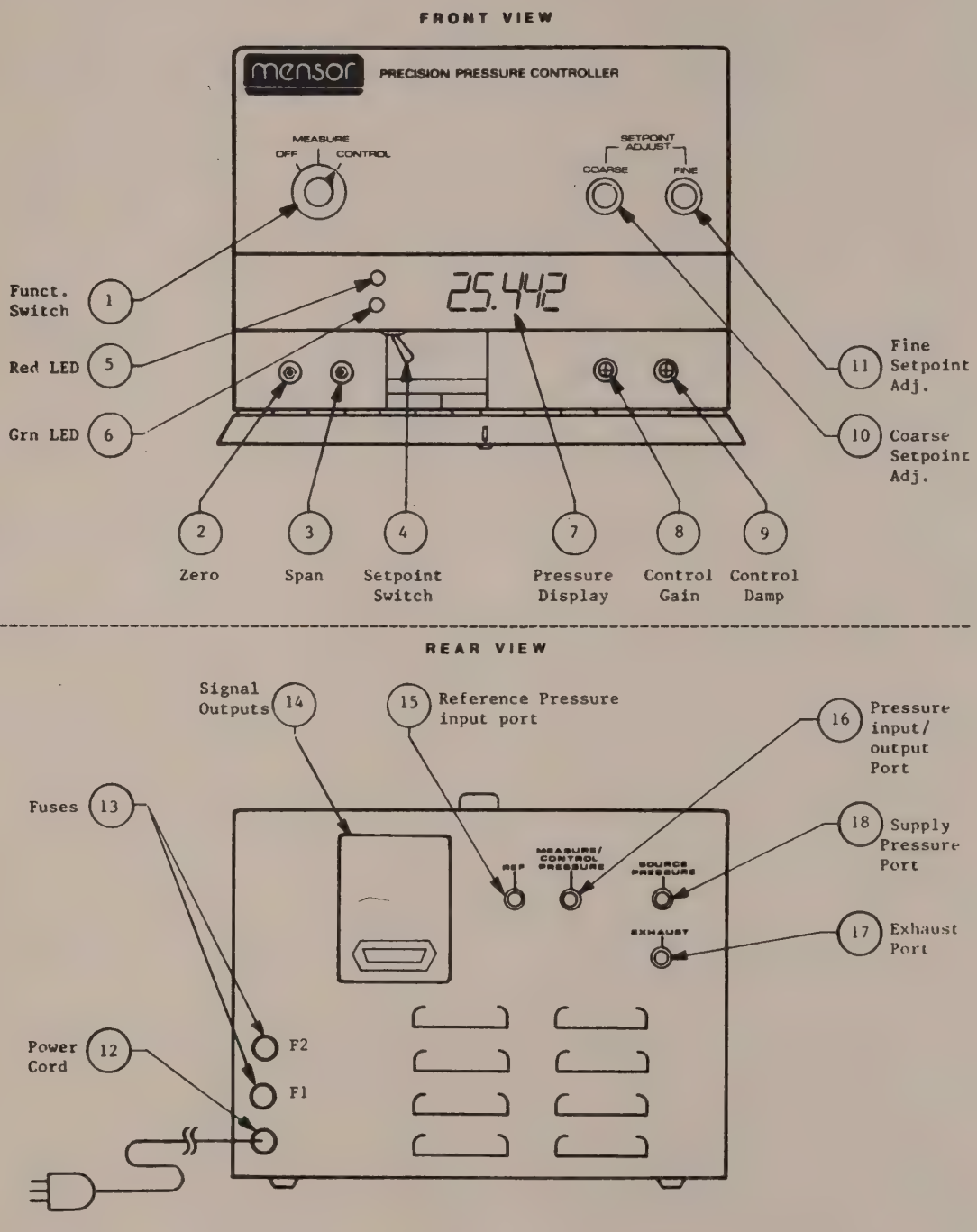


FIG. 2.2(A)

FRONT AND REAR CONTROLS AND CONNECTIONS
(See Table 2.2)

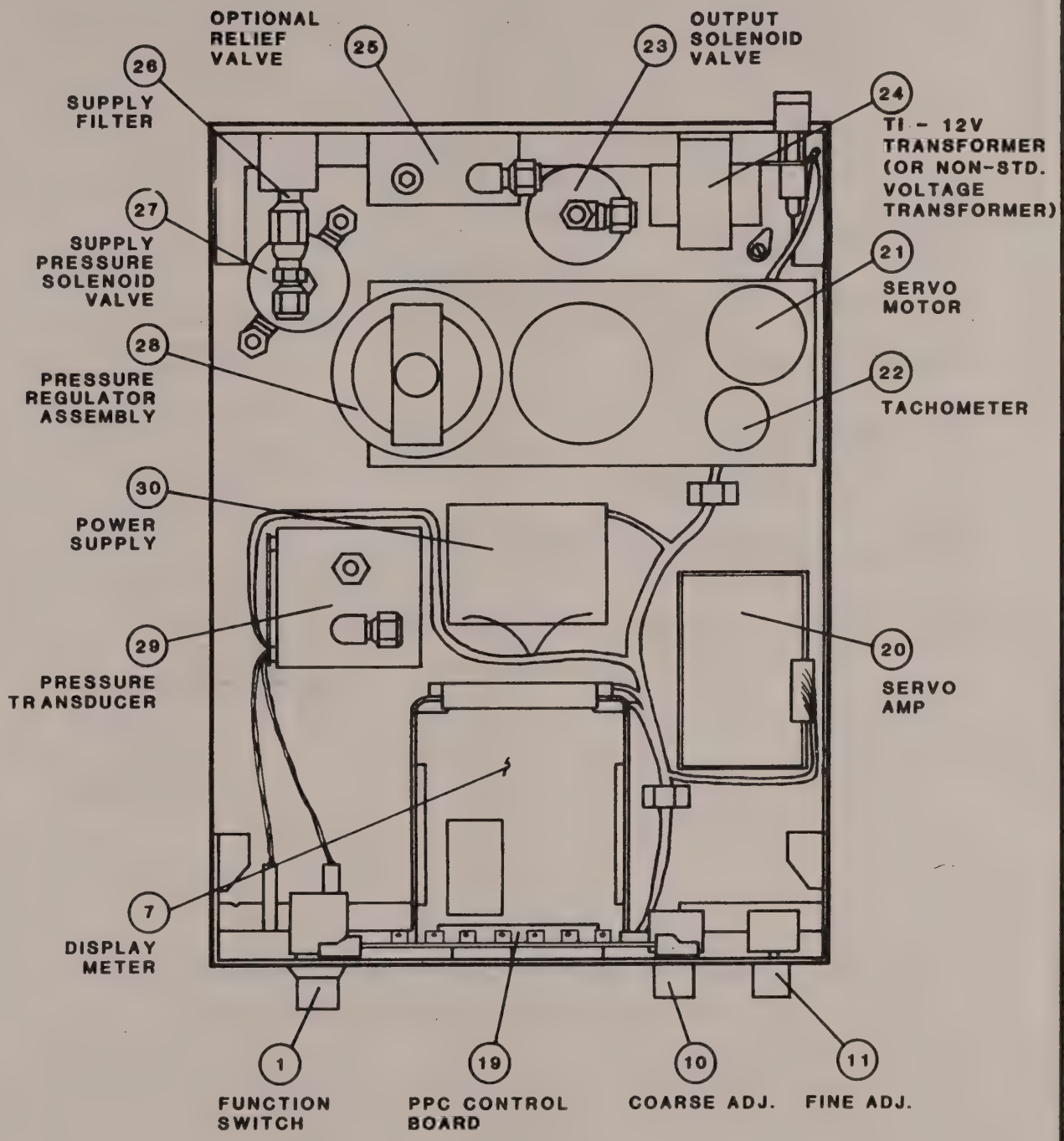


FIG. 2.2(B)

COMPONENT LAYOUT - TOP VIEW
(See Table 2.2)

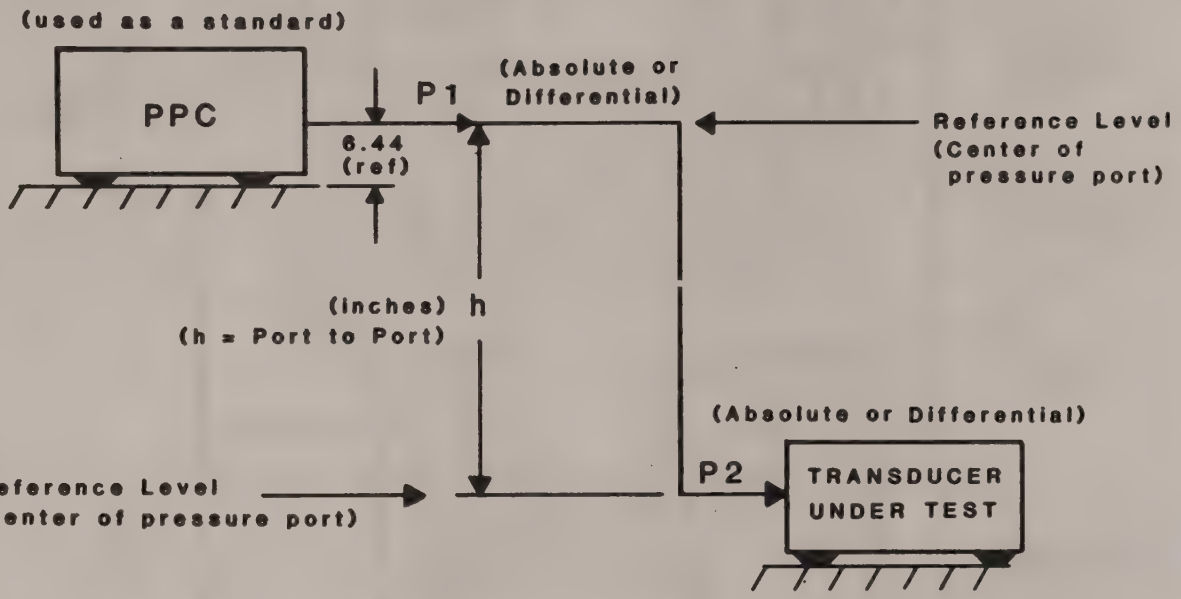
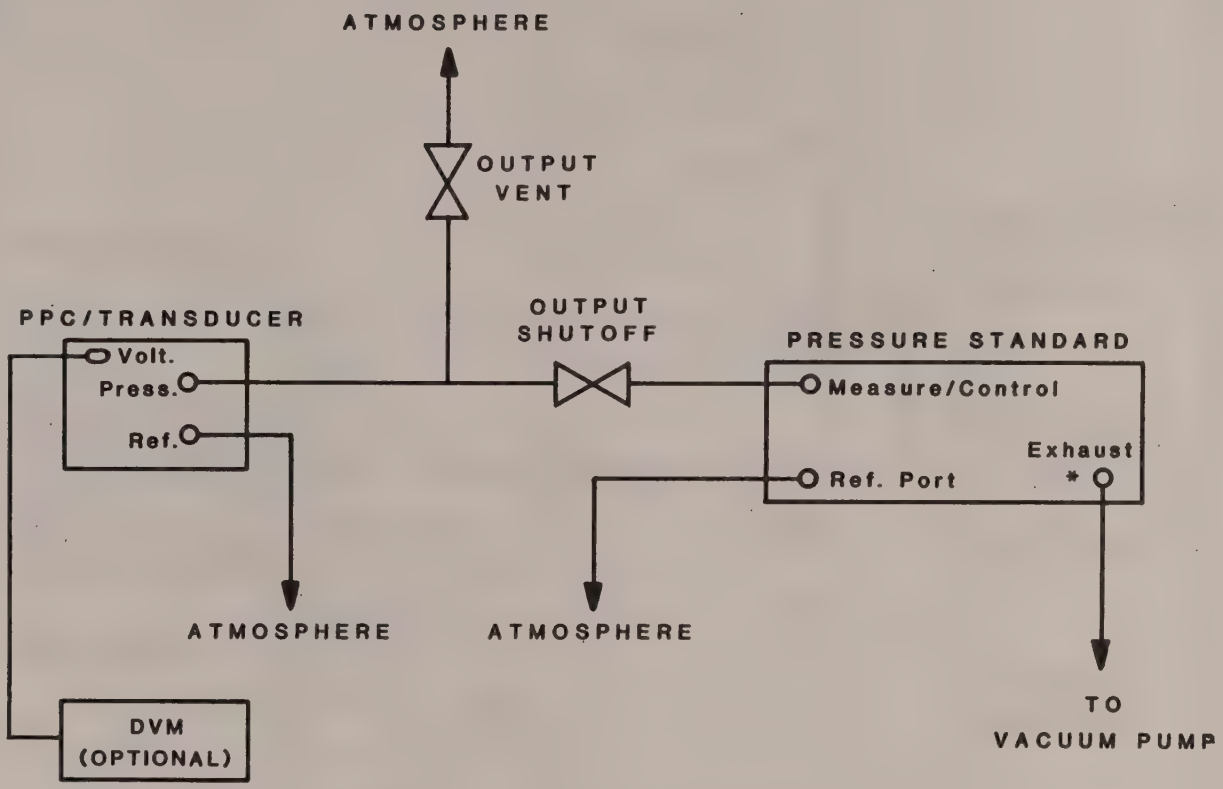


FIG. 3.4

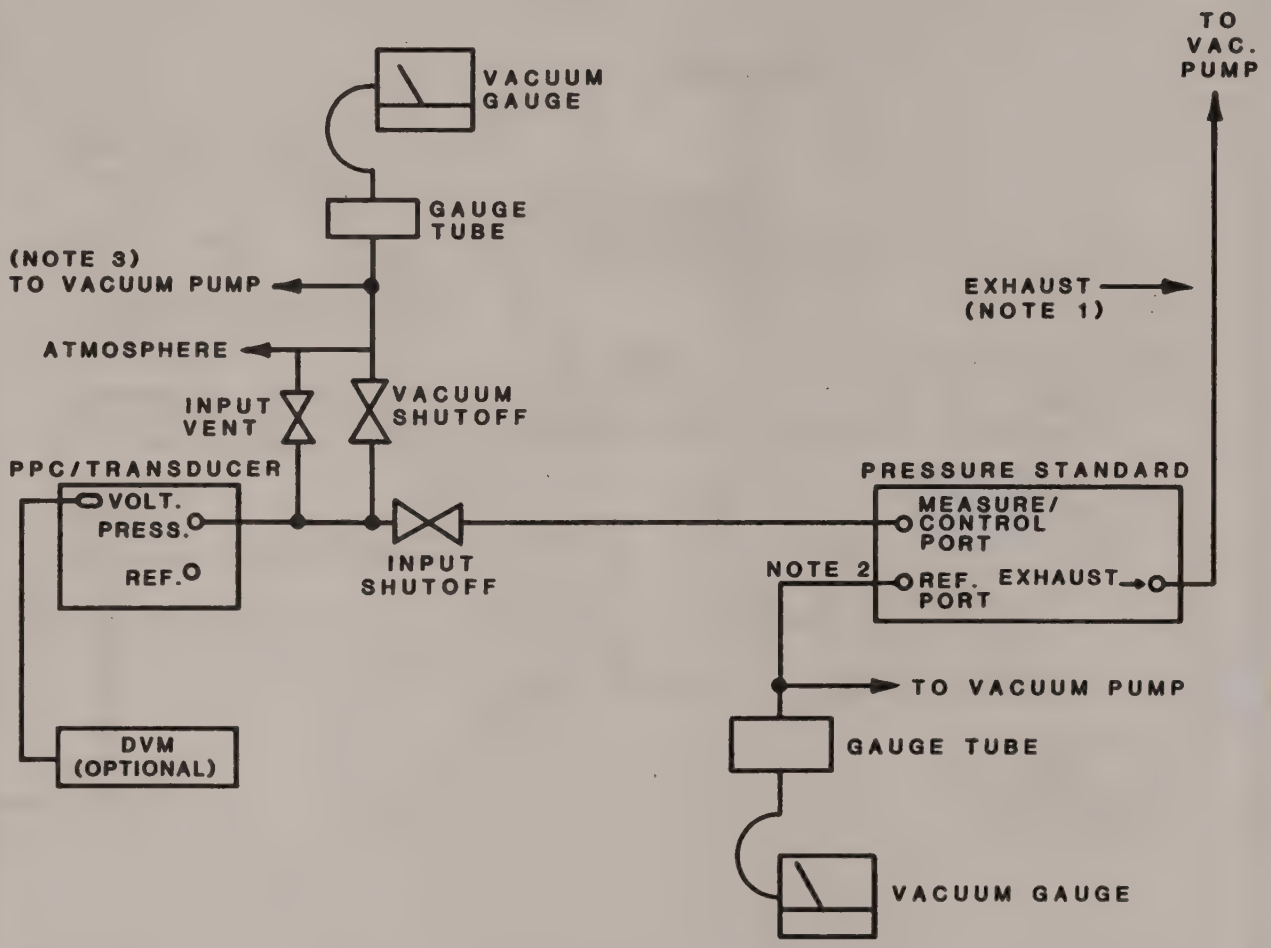
HEAD PRESSURE CORRECTION FOR GAS



* Vacuum is required when points at or below atmosphere are to be controlled.

FIG. 4.2(A)

DIFFERENTIAL PRESSURE CALIBRATION OF THE PPC/TRANSDUCER



NOTES:

1. VACUUM IS REQUIRED WHEN POINTS BELOW ATMOSPHERE ARE TO BE RUN.
2. THE VACUUM SYSTEM ON THE REF. PORT IS USED ONLY IF A DIFFERENTIAL PRESSURE STANDARD IS BEING USED.
3. THIS VACUUM PUMP IS USED TO SET "ZERO" ON THE PPC UNDER TEST AS WELL AS SET "ZERO" ON THE STANDARD.

FIG. 4.2(B)

ABSOLUTE PRESSURE CALIBRATION OF THE PPC/TRANSDUCER

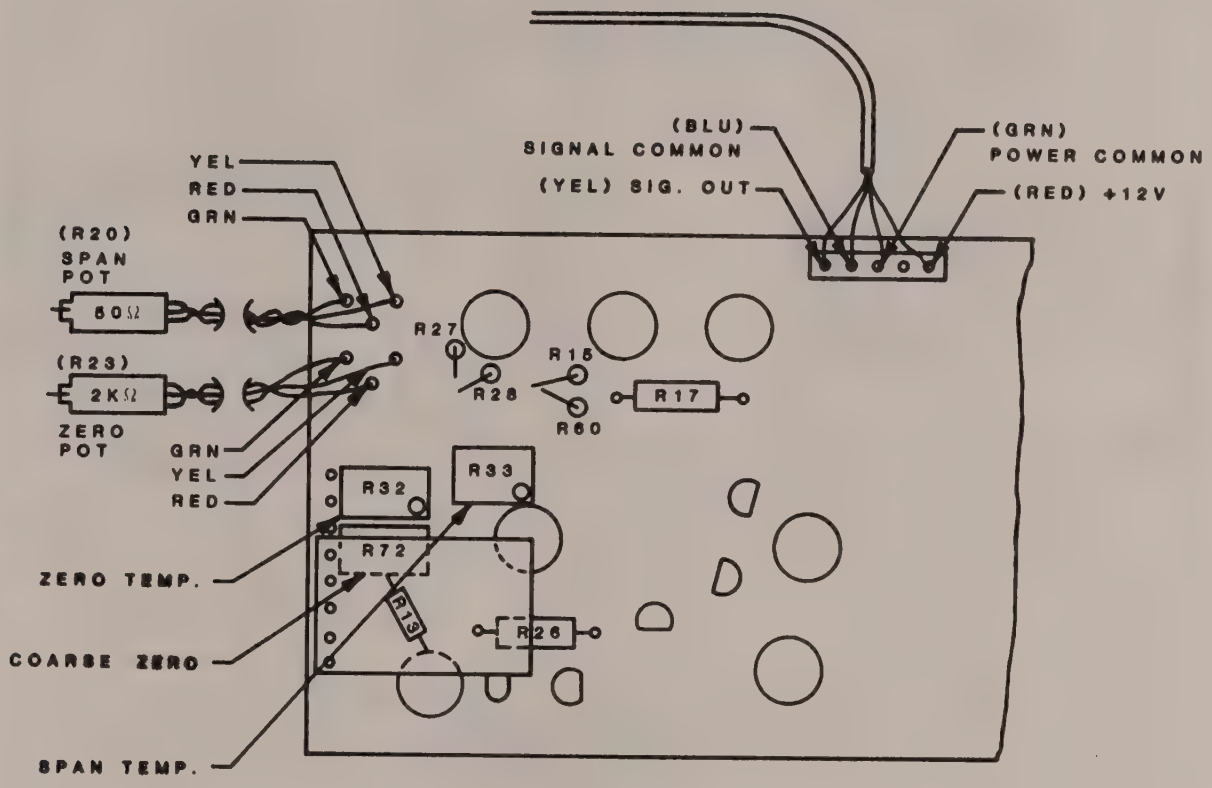


FIG. 4.3.1

SIGNAL CONDITIONING CIRCUIT BOARD

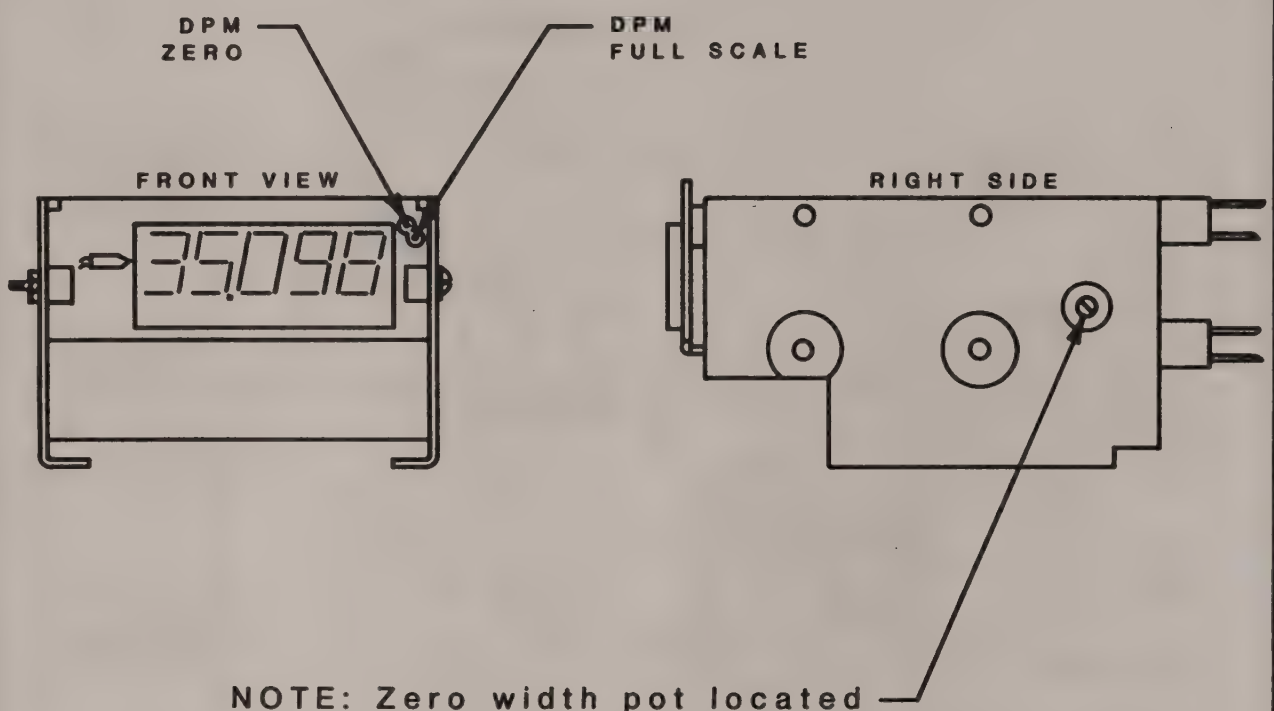
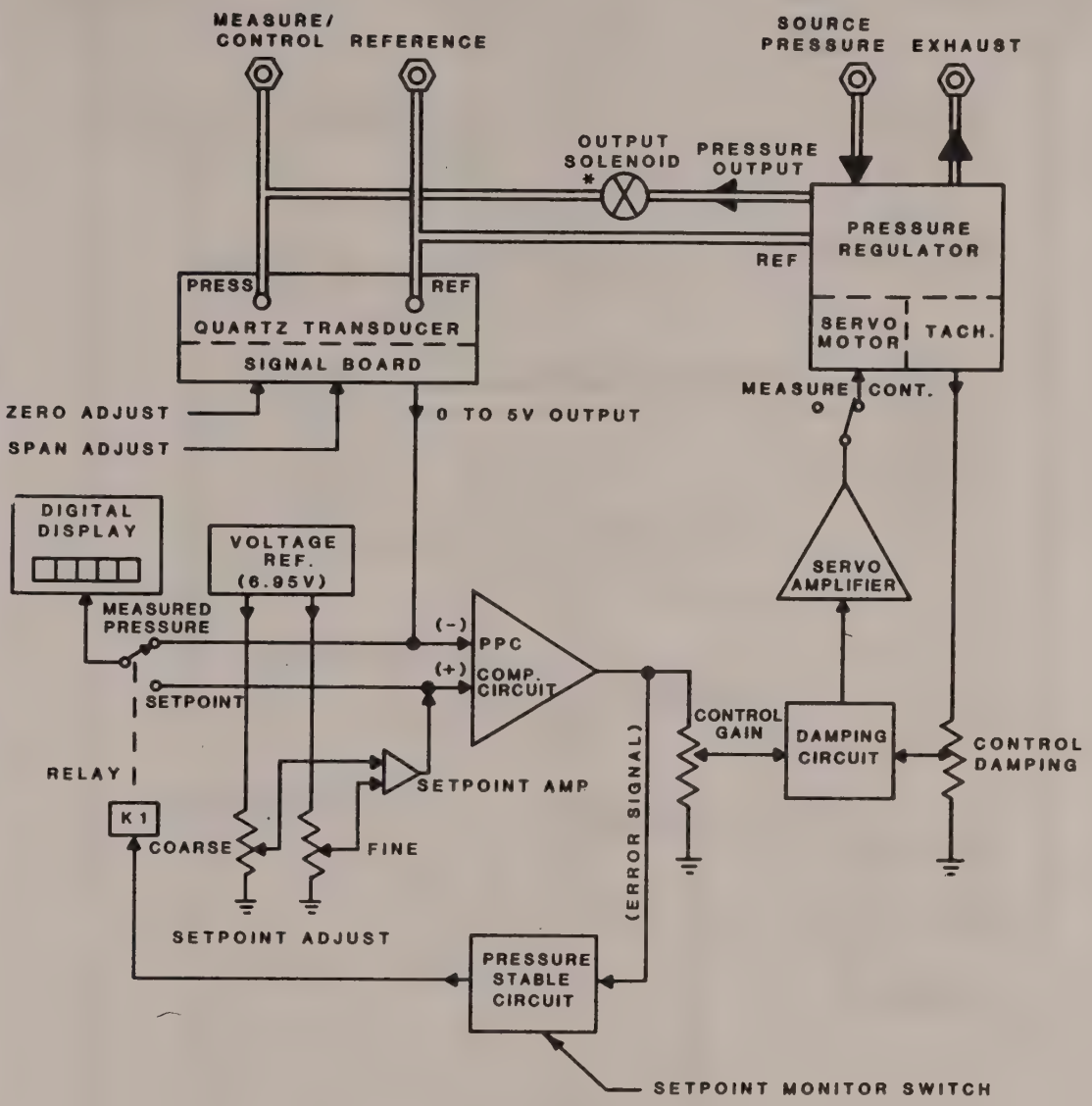


FIG. 4.3.2

ELECTRONUMERICS DPM



* SOLENOID VALVE IS CLOSED ONLY FOR MEASURE MODE.

FIG. 5.1

BLOCK DIAGRAM - PPC

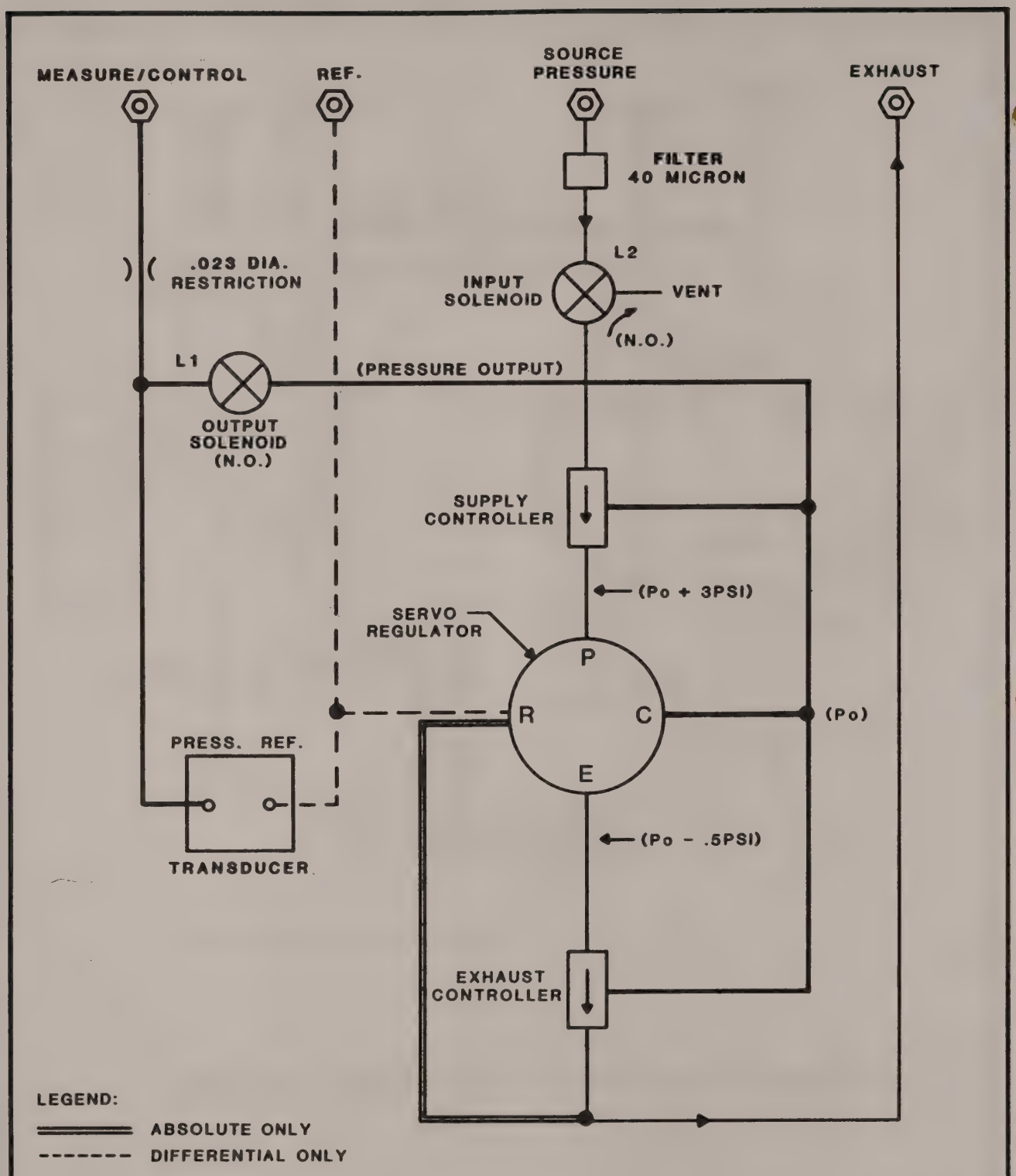


FIG. 5.4(A)

DIAGRAM - PNEUMATIC
PPC LOW PRESSURE CONTROLLER

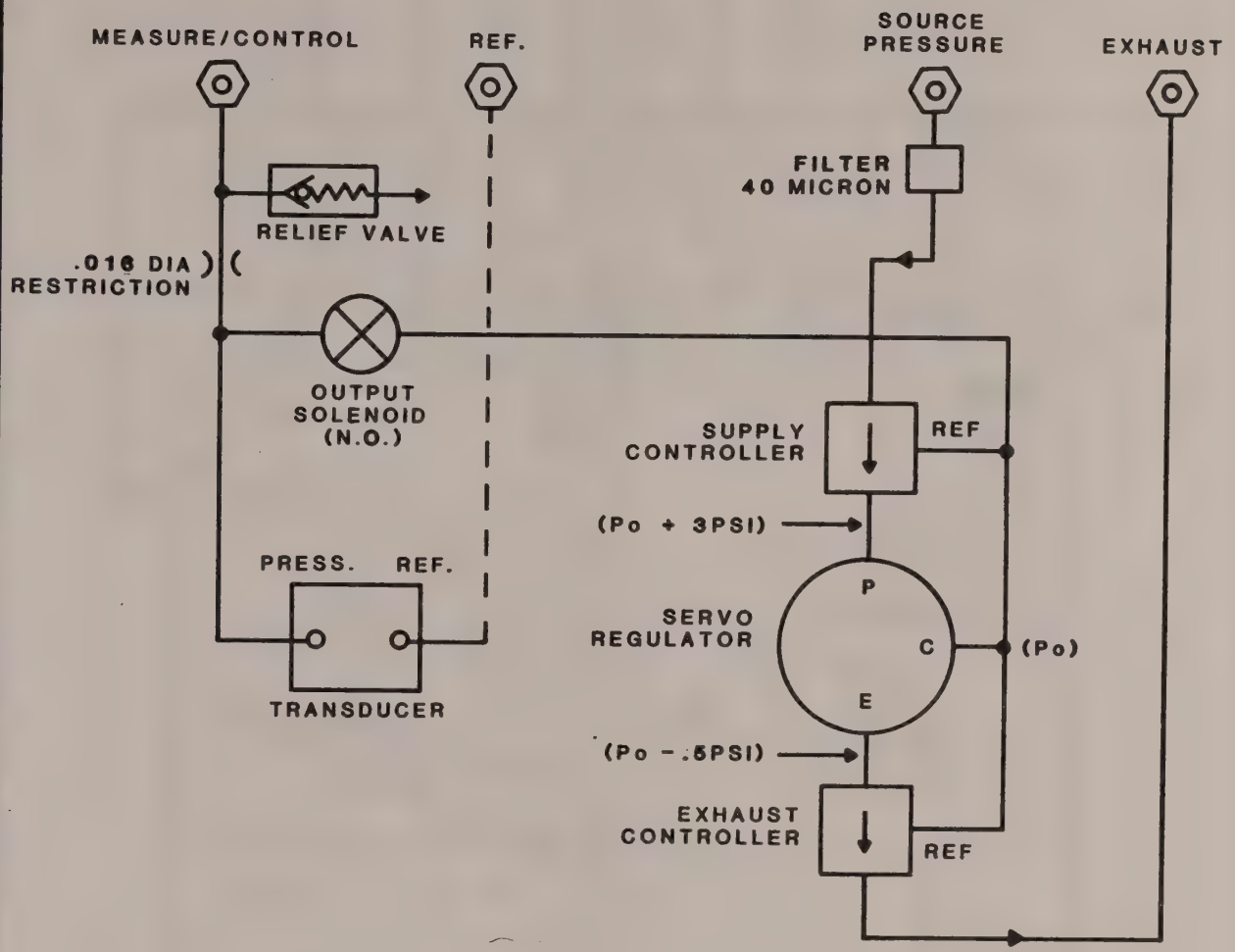


FIG. 5.4(B)

DIAGRAM - PNEUMATIC
PPC HIGH PRESSURE CONTROLLER

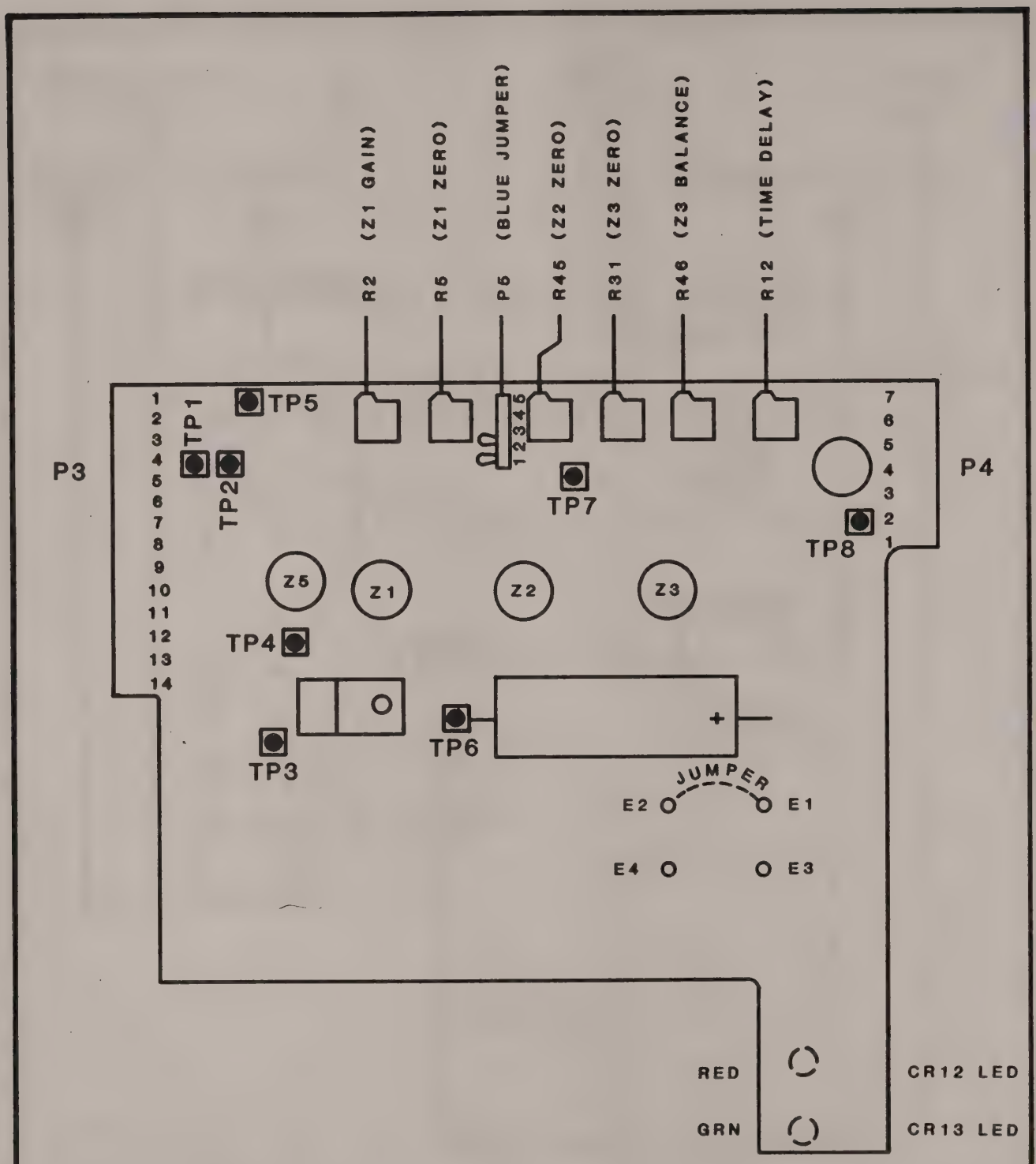


FIG. 5.5(A)

PPC CONTROLLER BOARD

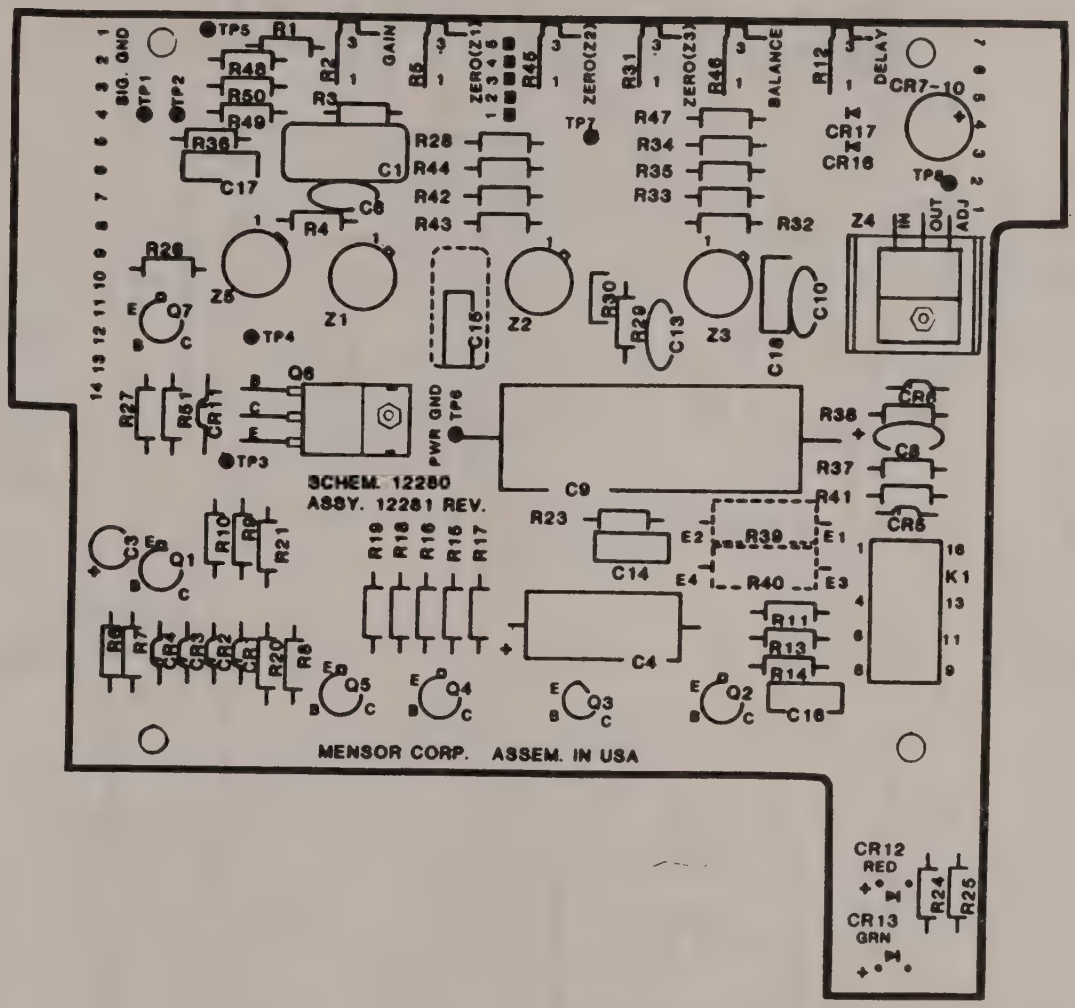


FIG. 5.5(B)

ASSEMBLY LAYOUT - PPC CONTROLLER BOARD

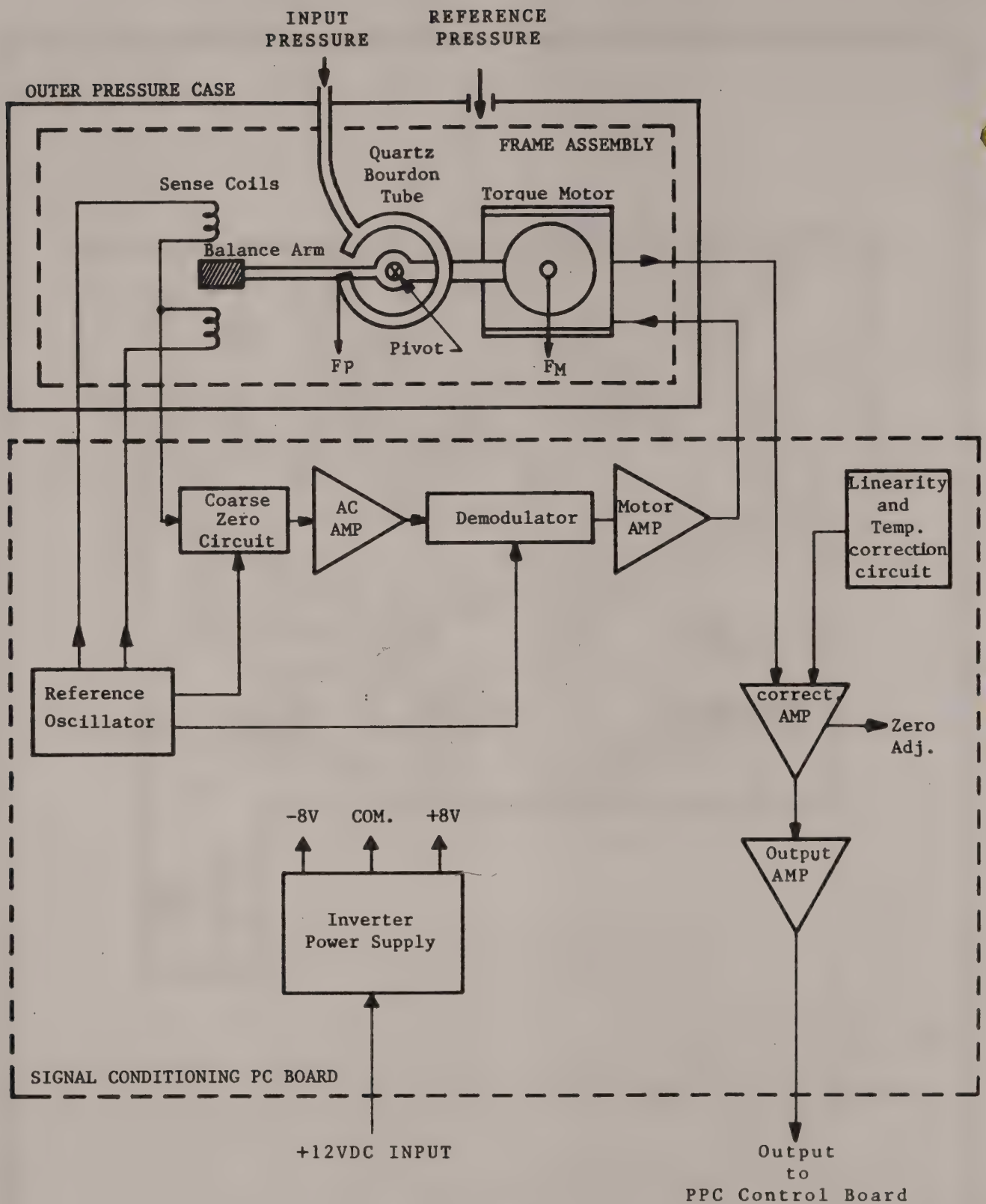


FIG. 5.8

TRANSDUCER BLOCK DIAGRAM

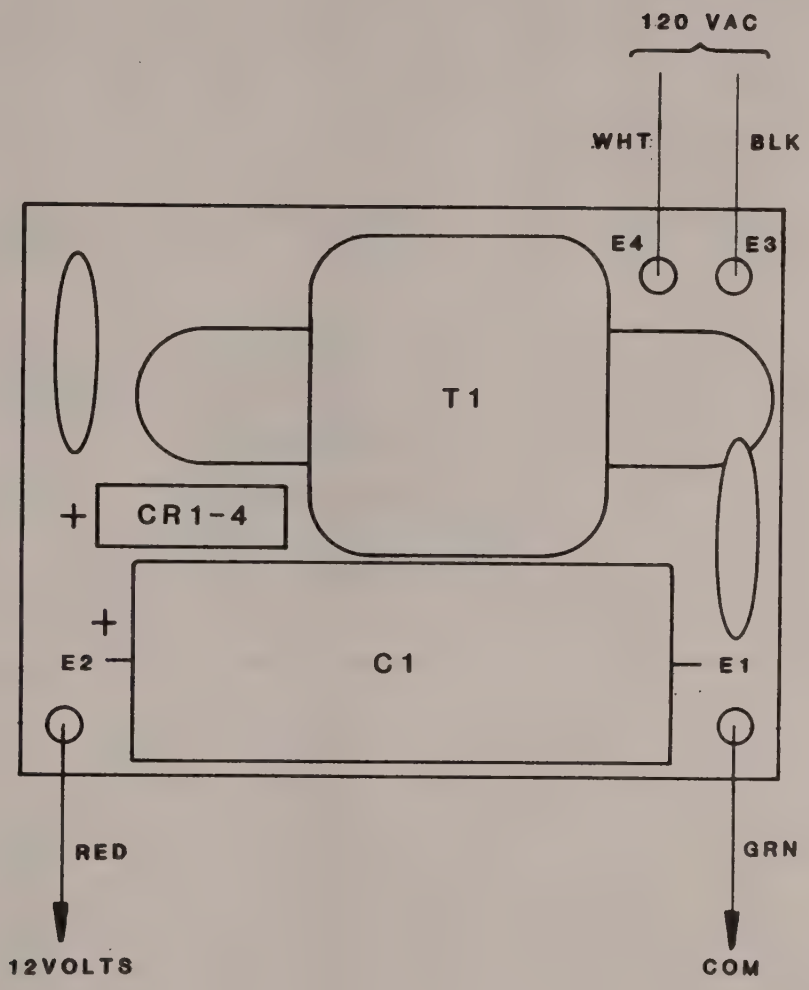
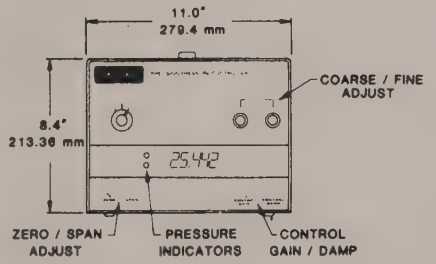
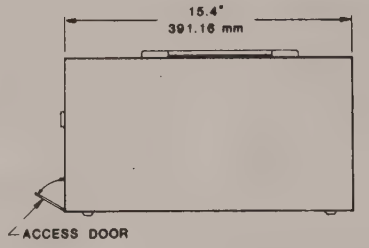


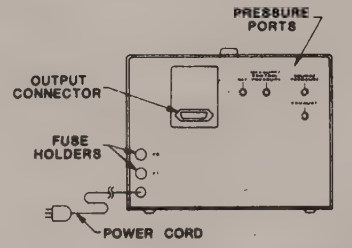
FIG. 5.10

12 VOLT POWER SUPPLY

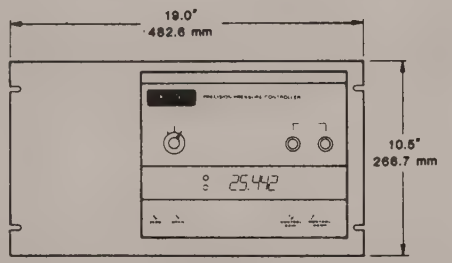
TABLE MODEL

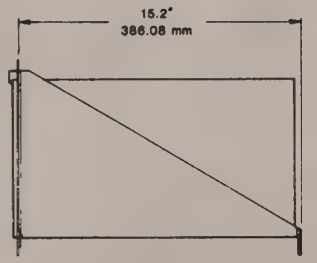


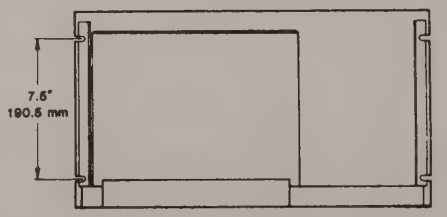




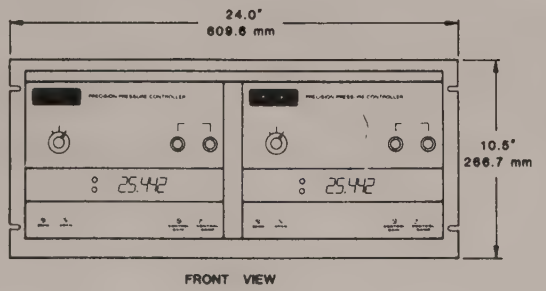
RACK PANEL MOUNTED

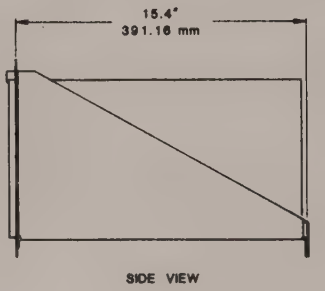






RACK PANEL MOUNTED





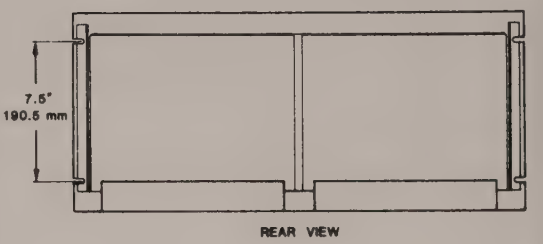


FIG. 7.3

PHYSICAL DIMENSIONS

A 12276001

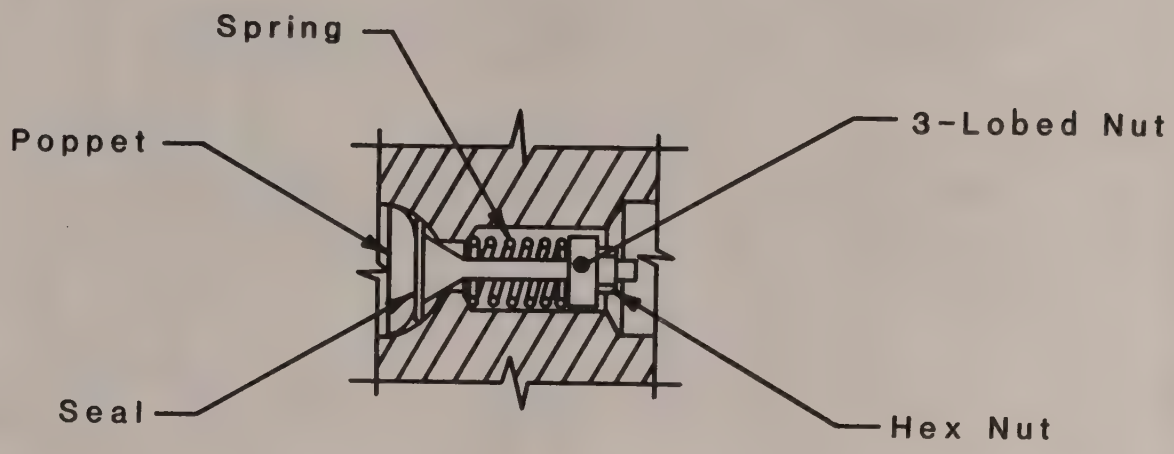


FIG. 7.4.3

RELIEF VALVE (CUT-A-WAY VIEW)

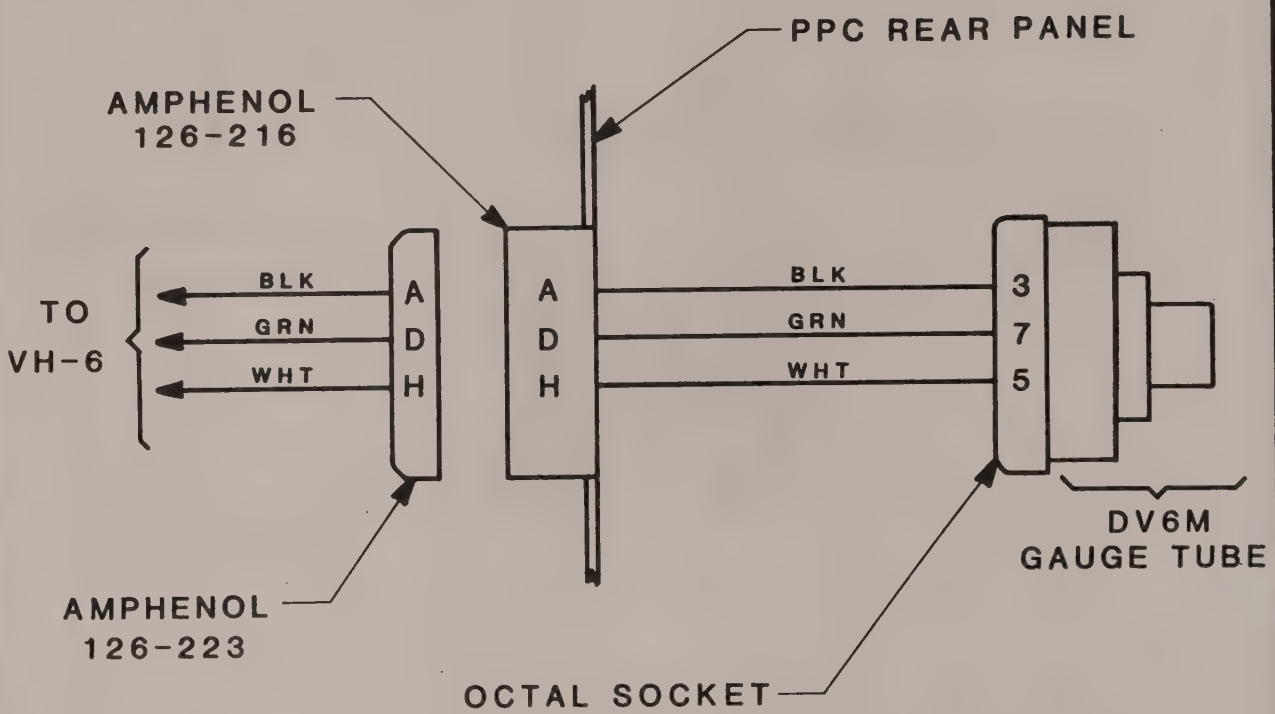


FIG. 7.5

DV6M THERMOCOUPLE VACUUM GAUGE

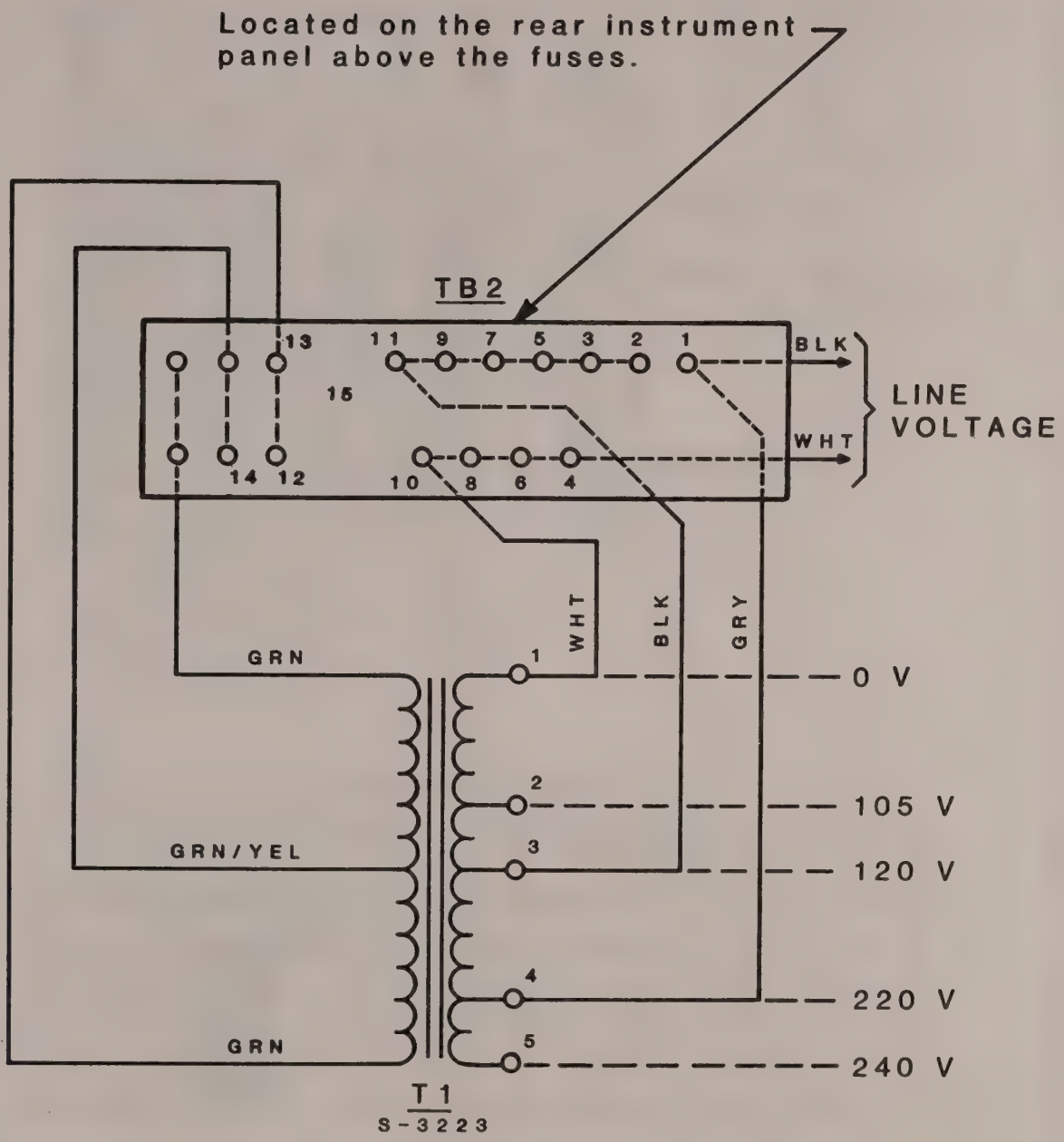
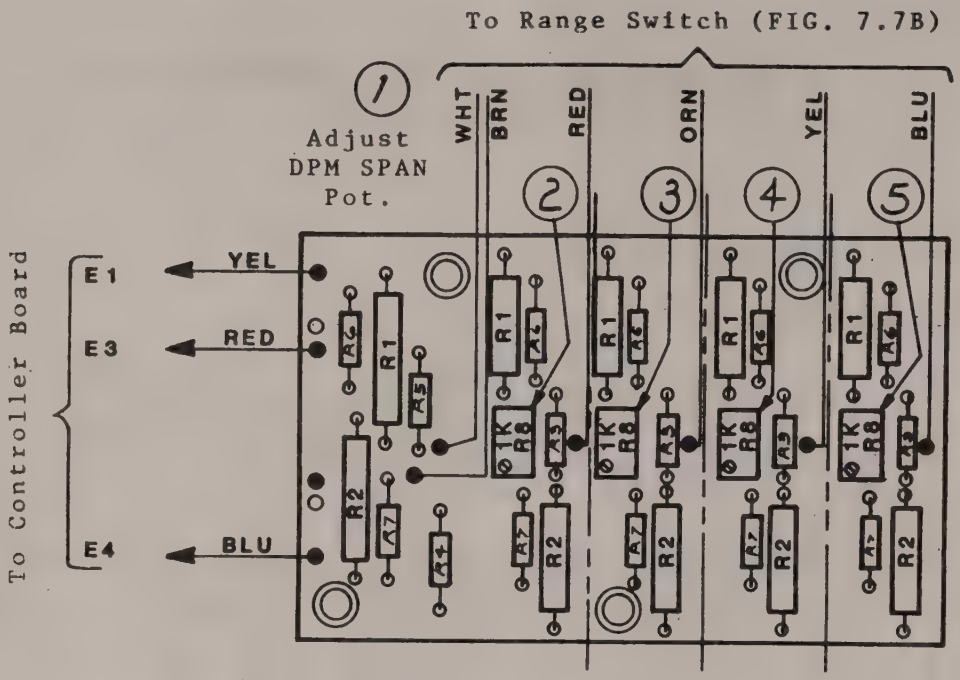


FIG. 7.6

NON-STANDARD VOLTAGE WIRING MODIFICATION



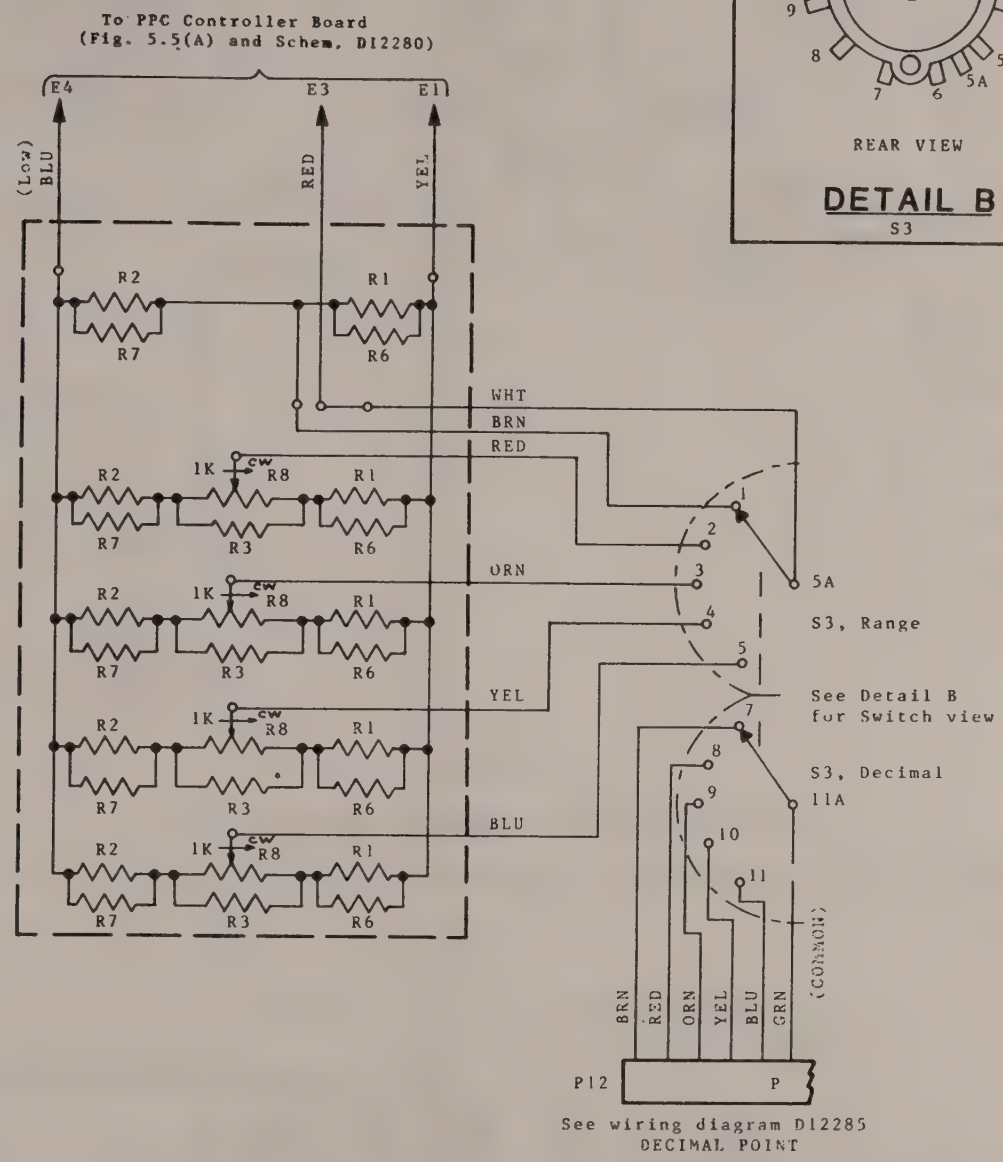
This board is mounted on the left side of the display meter.

RESISTOR VALUES

SWITCH POSITION	ENGINEERING UNITS	R1	R2	R3	R5	R6	R7
1							
2							
3							
4							
5							

FIG. 7.7(A)

PRESSURE UNITS BOARD



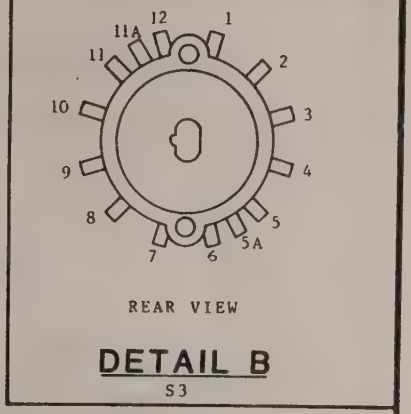


FIG. 7.7(B)

PRESSURE UNITS SWITCH WIRING

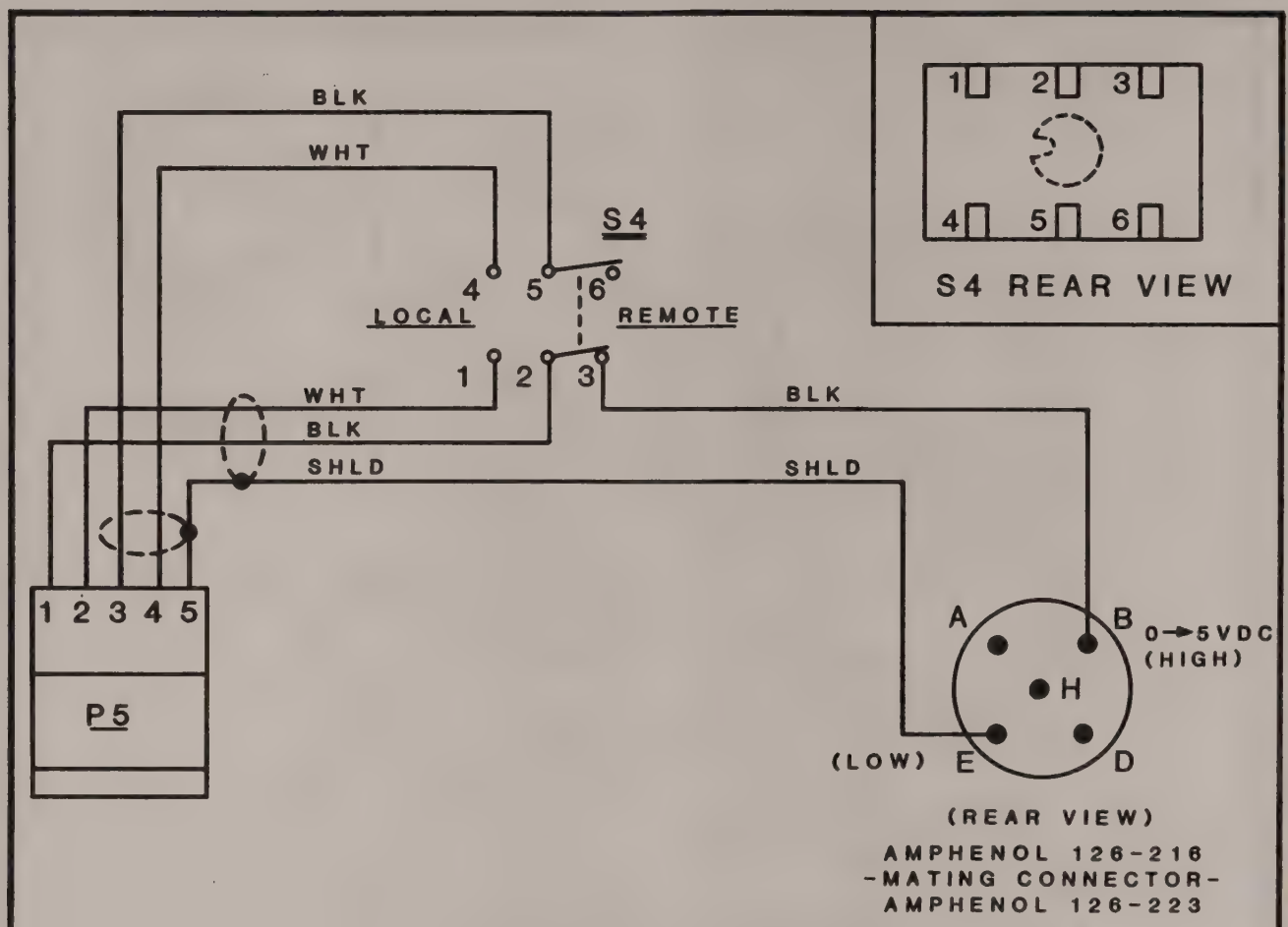


Fig 7.8(A)

REMOTE PRESSURE CONTROL WIRING DIAGRAM

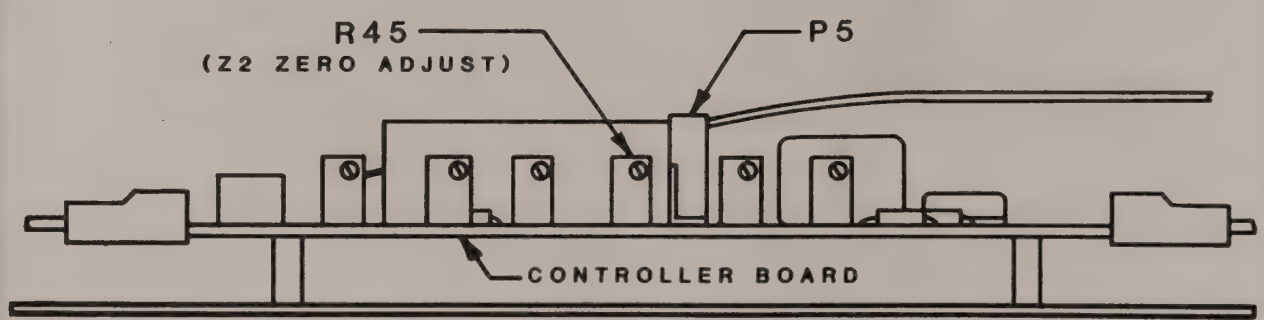


Fig. 7.8(B)

- APPENDIX B -

Tables

A 12276001

TABLE 2.2

CONTROLS, CONNECTIONS, AND LAYOUT

*REF	ITEM	DESCRIPTION	FUNCTION
1	Function Switch	3 position rotary switch	This switch applies power to the PPC for the pressure "Measure" mode or the "Control" mode of operation.
2	Zero	Screwdriver adjustment	A multi-turn pot used to set the display to indicate 00000 when zero or equal differential pressure is applied to the PPC.
3	Span	Screwdriver adjustment	A multi-turn pot used to set the proper full scale indication when a calibrated full span pressure is applied to the PPC pressure ports.
4	Setpoint Monitor	Momentary Switch	A spring loaded momentary switch to transfer the display from the actual measured pressure to the desired setpoint. A red LED will be indicated when this switch is pushed to the left.
5	red LED	upper light, red LED	This red light indicates that the display is indicating the desired pressure setpoint, as set by pots 10 and 11.
6	green LED	lower light, green LED	This green light indicates that the display is indicating the actual pressure being applied to the PPC transducer.
7	Display	7-segment planar indicators	Displays digital readout for a maximum count of 39.999 (optional 50,000). Decimal point is set to indicate value of a direct reading pressure. Sign is displayed automatically for negative pressures.
8	Control Gain	one turn Pot	This pot sets the gain of the pressure control servo loop for most accurate control.
9	Control Damping	one turn Pot	This pot sets the damping of the pressure control servo loop for proper stability of the controlled output pressure.

* Item numbers on Figure 2.2(A) and 2.2(B)

TABLE 2.2 continued.....

*REF	ITEM	DESCRIPTION	FUNCTION
10	Coarse Adjust	10 turn Pot	This pot changes the set point pressure, about 10 percent per turn. (from zero to full scale in 10 turns.)
11	Fine Adjust	10 turn Pot	This pot provides a fine adjustment of the setpoint. (about 0.1 percent of span per turn.)
12	Power Cord	115V AC Power Cord	This is a 5 foot long #18 gauge power cord with a 3-prong grounded 115V AC plug.
13	Fuses	Fuse holders	Two fuse holders provide protection for both sides of the power line. 1 amp AGC fuses are used for 115V AC, 1/2 amp AGC for 230V AC.
14	Outputs	24 pin connector Amphenol #57-40240	External connection to analog and digital (BCD) outputs of the measured pressure.
15	Reference input	Female 1/8 inch NPT pressure port	Connection for the reference of a differential pressure, or atmospheric pressure for a gauge pressure instrument. On absolute units, this port is not connected.
16	Pressure input/ output	Female 1/8 inch NPT pressure port	Connection for posituve input, and/or controlled output, pressure. (Differential or absolute pressure.)
17	Exhaust	Female 1/8 inch NPT pressure port	Connection for a vacuum pump, used to provide a low pressure exhaust for the servo regulator when controlling pressures at or below atmospheric pressure.
18	Supply Pressure	Female 1/8 inch NPT pressure port	Connection for a source of clean instrument air at a pressure about 5% to 20% higher than the full scale pressure control range.
19	PPC Control Board	Electronic printed circuit board with calibration pots	This pc board is mounted on the back of the front panel. It produces an error signal for the pressure control servo loop. This signal is derived from comparing the desired setpoint pressure with the actual pressure signal out of the transducer.

TABLE 3.2.1 - CONVERSION CHART

The following conversion chart should aid in converting millitorr to pressure units.

MILLITORR	IN.HGA	PSIA	MILLITORR	IN.HGA	PSIA
1000	.03937	.01934	70	.00276	.00134
900	.03542	.01740	65	.00256	.00127
800	.03150	.01547	60	.00236	.00116
700	.02756	.01336	55	.00217	.00106
600	.02362	.01160	50	.00197	.00097
500	.01969	.00967	45	.00177	.00087
400	.01575	.00773	40	.00157	.00077
300	.01181	.00580	35	.00138	.00068
250	.00984	.00483	30	.00118	.00058
200	.00787	.00387	25	.00098	.00048
175	.00689	.00338	20	.00079	.00039
150	.00591	.00290	15	.00059	.00029
140	.00551	.00271	10	.00039	.00019
130	.00512	.00251	9	.00035	.00017
120	.00472	.00232	8	.00031	.00015
110	.00433	.00213	7	.00028	.00013
100	.00394	.00193	6	.00024	.00012
95	.00374	.00184	5	.00020	.00010
90	.00354	.00174	4	.00016	.00008
85	.00335	.00164	3	.00012	.00006
80	.00315	.00155	2	.00008	.00004
75	.00295	.00145	1	.00004	.00002

TABLE 3.4.1 - GAS DENSITY AT 23°C

GAS		α (PRESS. RATIO PER INCH)
Air	(Dry)	2.9315×10^{-6}
Argon	(A)	4.0443×10^{-6}
Carbon Dioxide	(CO2)	4.4824×10^{-6}
Helium	(He)	4.0466×10^{-7}
Hydrogen	(H2)	2.0379×10^{-7}
Nitrogen	(N2)	2.8355×10^{-6}
Oxygen	(O2)	3.2402×10^{-6}

NOTE: The change in density ratio due to temperature changes is insignificant and may be ignored. However, for large changes in ambient temperature (over 15°C) a new α may be calculated.

where: $\alpha 2 = \alpha [1 + .003661 (23^{\circ} - T2^{\circ})]$

$\alpha 2$ = New α at T2

T2 = actual temperature of gas (°C)

TABLE 7.1

AUXILIARY INPUT/OUTPUT CONNECTOR

PIN	FUNCTION
1	1
2	2
3	4
4	8 (10^0)
5	10
6	20
7	40
8	80 (10^1)
9	100
10	200
11	400
12	800 (10^2)
13	1K
14	2K
15	4K
16	8K (10^3)
17	10K
18	20K (10^4)
19	Inhibit (ground to hold) *(40K)
20	Polarity (high for positive)
21	Data Ready (high equals stable)
22	High
23	Low (Analog output-voltage)
24	Digital COMMON

*When the 50,000 count option is installed in the PPC, Pin 19 is used for 40K in place of the Inhibit function.

NOTE: The mating cable connector (supplied by Mensor Corporation) is Amphenol #57-30240.

TABLE B-1

SPAN RANGES FOR VARIOUS PRESSURE UNITS

Span range, min-max	Span	Least significant digit	Full-span display
	0-1	0.0001	1.0000
	0-2	0.0001	2.0000
	0-3	0.0001	3.0000
	0-4	0.0001	4.0000
	0-5	0.001	5.000
	0-6	0.001	6.000
	0-8	0.001	8.000
	0-10	0.001	10.000
	0-20	0.001	20.000
	0-30	0.001	30.000
	0-40	0.001	40.000
	0-50	0.01	50.00
	0-60	0.01	60.00
	0-80	0.01	80.00
	0-100	0.01	100.00
	0-200	0.01	200.00
	0-300	0.01	300.00
	0-400	0.01	400.00
	0-500	0.1	500.0
	0-600	0.1	600.0
	0-800	0.1	800.0
	0-1000	0.1	1000.0
	0-2000	0.1	2000.0
	0-3000	0.1	3000.0
	0-4000	0.1	4000.0
	0-5000	1	5000
	0-6000	1	6000
	0-8000	1	8000
	0-10000	1	10000

Pressure units	Conversion factor
mm H_2O	(1) 703.08
in.H_2O	(1) 27.68
ft.seawater	2.2472
kilopascals	6.8947
bars	0.068947
millibars	68.947
mm Hg	(2) 51.715
in.Hg	(2) 2.0360
psi	1.0
atm.	.0680452

PSI x conversion factor = pressure unit

Min absolute pressure span = 0-4 PSIA

Max absolute pressure span = 0-500 PSIA

(1) at 4°C
(2) at 0°C

TABLE - B-2

ALTITUDE & AIR SPEED PRESSURE TABLE

Altitude	
Feet	Inches of Mercury
- 3,000	33.3107
- 2,000	32.1481
- 1,000	31.0185
0	29.9213
500	29.3846
1,000	28.8557
1,500	28.3345
2,000	27.8210
2,500	27.3151
3,000	26.8167
4,000	25.8418
5,000	24.8959
6,000	23.9782
8,000	22.2249
10,000	20.5769
12,000	19.0293
14,000	17.5773
15,000	16.8858
16,000	16.2164
18,000	14.9421
20,000	13.7501
22,000	12.6363
25,000	11.1035
30,000	8.8854
35,000	7.0406
40,000	5.5380
45,000	4.3550
50,000	3.4247
60,000	2.1178
70,000	1.3105
80,000	0.8155
90,000	0.5108
100,000	0.3219

Airspeed	
Knots	Inches of Mercury
60	0.1727
80	0.3075
100	0.4814
110	0.5832
120	0.6950
130	0.8168
140	0.9488
150	1.0910
175	1.4918
200	1.9589
225	2.4943
250	3.1002
275	3.7792
300	4.5343
325	5.3687
350	6.2859
375	7.2900
400	8.3850
425	9.5758
450	10.8675
475	12.2654
500	13.7756
525	15.4045
550	17.1590
575	19.0465
600	21.0749
650	25.5893
700	30.7642
750	36.5662
800	42.9378
850	49.8423
900	57.2554
1,000	73.5454

- APPENDIX C -

Schematics

POWER AMP BOARD
PART NO. C 10085-002

PREAMP

A*P1 A*P4 A*P5

+17.0V

R4 20K
R8 562K
R31 10
R25 SEE NOTE 7
R26 33.2K
Z1 SSS741CJ
Q7 2N2222 (EPL 318)
C7 50 15V
-13.7V
R29 2.21K
Q1 2N3819
C11 0.47
C12 01
R22 100
R23 SELECTED
E5 E6 E7 E8
+4.3V
R27 4.75K
R19 47.5K
R30 4.75K
-17.0V
C17, 50 15V
CR2 1N914
C9 12pF
R15 SELECTED
R16 20K
+36 -1.6
R9 15K
R34 511K
R35 200K
+30 -7
CR7-11 FW100
AC AC (+) (-)
+25V -25V
C15 250 50V
C16 250 50V
R21 121
Q8 2N5951
Q9 2N5951
CR5 CR6
R33 121
Q5 2N2222 (EPL 318)
Q6 2N5447
-17V
C13 .05
C14 .05
+17.0V
-17.0V
Q3 2N5447
R11 12.1K
R13 33.2K
R20 51.1K
R18 3.92K
R12 43.2K
R17 1K
RE 100K
+17 V
NC.
A*P6 (REF)

POWER SUPPLY
PREAMP & POWER SUPPLY BOARD
PART NO. C10663-001

A*P3 (REF)
A*P7 NOTE 6

RED BLU NC GRN
GRN (-004 ONLY)
WHT BLK

C1 01
R1 10K
-5.4V
Q1 2N5447
+6.2V
C4 50,16V
20V
8V
R2 36.5
R7 4.75K
R10 1.5K
R3 3.65K
C2 140 6V
R4 3.65K
-4.4V
R8 4.75K
R11 1.5K
Q2 2N5447
-5.7V
C5 50 16V
20V
R5 82K
+5.0V
C3 50,16V
R6 20K
Q4 2N5447
8V
R14 825
R13 825 (A*P5)
R15 1Ω 3W
≈ 2V
C6 75 30V (NP)
R16 1Ω 3W
Q5 TIP 33 LOWER TRANSISTOR
VIO WHT YEL
CR1-4 FW100
C7, .05
9V
AC
(A*P5) UPPER TRANSISTOR
Q6 TIP 33
BRN ORN GRY

11.4VAC GRN GRN
115VAC BLK BLK
18VAC RED/YEL
18VAC RED
BLU
8VAC
B10108-002 TI
A*P5

BLU WHT BLK
RED BRN
OL2 (WHT) OL1 (BLK)
115V 50/60HZ
1.5 400V
M
115V
A*P2

NOTES: (UNLESS OTHERWISE SPECIFIED)
1. RESISTANCE VALUES ARE IN OHMS, ¼W 1%.
2. CAPACITANCE VALUES ARE IN MICROFARADS.
3. R23 SELECTED FOR |VOUT DC| OF Z1 > .5V. R15 (APPROX. 2M) SELECTED FOR MINIMUM DC OFFSET OUT OF CHOPPERS.
4. OVERALL GAIN IS THE RATIO OF RMS FROM Q5-C TO Q6-C TO E_{IN} AT A1P1-5.
5. (*) THE MODULE NUMBER SHOULD BE INSERTED HERE WHEN SPECIFIED IN HIGHER ASSEMBLIES. (EX. A5P1)
6. P3 & P7 ARE USED ON RATE AMPLIFIER ASSY. ONLY (10661-001 & 10661-002). OTHERWISE BLUE WIRES ARE CUT OFF.
7.

DASH NO.	R25	Z1 GAIN	OVERALL GAIN (NOTE 4)
-002	24.3K	244	~17,200
-004	13K	131	~9,000

DASH NO.	AMPLIFIER ASSY.
~~-001~~	~~10660-001, ANALOG SERVO~~
-002	10660-002, DIGITAL SERVO
~~-003~~	~~10660-003, A/VSI~~
-004	10660-004, PPC

2N3819 (D G S)
2N2222-EPL318 (E B C QR)
SSS 741CJ (1 2 3 4 5 6 7 8)
BOTTOM VIEW
TOP VIEW
2N5951 (S D G)
TIP 33 (B C E)

REVISIONS

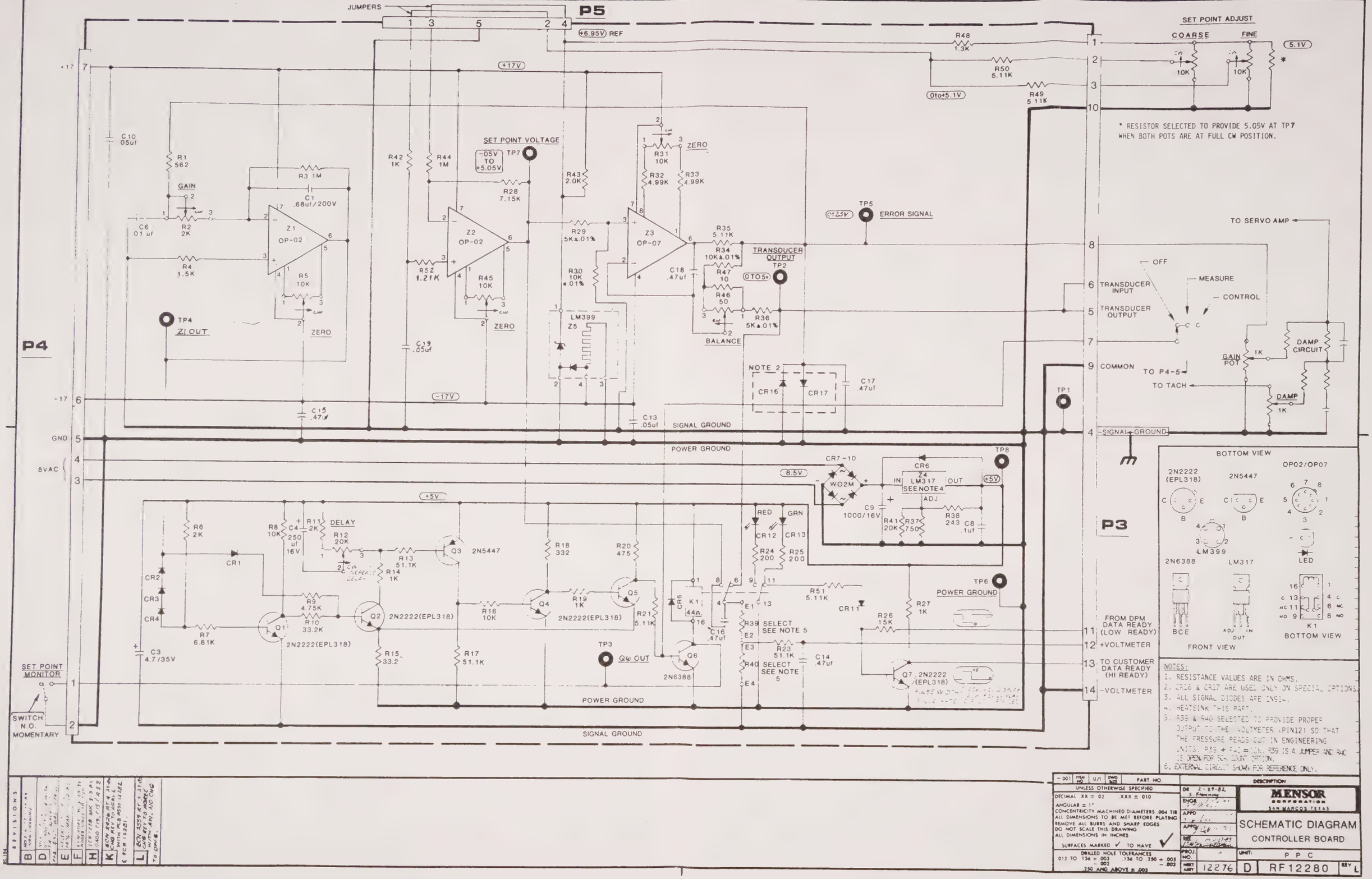
A	IN WHITE	
B	ECN 2380 SPACING CHANGED TO 0.100	
C	1. DELETE R7 & C10 2. ADD R7 4.75K 1/4W 1% 3. ADD R10 1.5K 1/4W 1% 4. ADD R11 1.5K 1/4W 1% 5. ADD C5 50 16V 6. ADD R8 4.75K 1/4W 1% 7. ADD C4 50 16V 8. ADD R5 82K 1/4W 1% 9. ADD C3 50 16V 10. ADD R6 20K 1/4W 1%	
D	ADDED Q8 Q9	
E	ECN 2380 REV C TO D ADDED 10423 TO N/A	
F	ECN 2380 REV D TO E ADDED 10423 TO N/A	
G	ECN 2380 REV E TO F ADDED 10423 TO N/A	
H	ECN 2380 REV F TO G ADDED 10423 TO N/A	
J	CHANGES MADE ON PARTS LIST AND SCHEMATIC DIAGRAM 1) ADDED R34 511K 2) ADDED R35 200K 3) CHANGED R9 TO 15K 4) ADDED C9 12pF 5) CHANGED R15 TO SELECTED 6) ADDED CR2 1N914 7) CHANGED R16 TO 20K 8) ADDED CR7-11 FW100 9) ADDED C15 250 50V 10) ADDED C16 250 50V 11) ADDED R21 121 12) ADDED R33 121 13) ADDED Q8 2N5951 14) ADDED Q9 2N5951 15) ADDED CR5 CR6 16) ADDED C13 .05 17) ADDED C14 .05 18) CHANGED R23 TO SELECTED 19) CHANGED R27 TO 4.75K 20) CHANGED R30 TO 4.75K 21) CHANGED R22 TO 100 22) CHANGED R11 TO 12.1K 23) CHANGED R13 TO 33.2K 24) CHANGED R20 TO 51.1K 25) CHANGED R18 TO 3.92K 26) CHANGED R12 TO 43.2K 27) CHANGED R17 TO 1K 28) CHANGED RE TO 100K 29) CHANGED R19 TO 47.5K 30) CHANGED R26 TO 33.2K 31) CHANGED R25 TO SEE NOTE 7 32) CHANGED R4 TO 20K 33) CHANGED R8 TO 562K 34) CHANGED C11 TO 0.47 35) CHANGED C12 TO 01 36) CHANGED C7 TO 50 15V 37) CHANGED C17 TO 50 15V 38) CHANGED Q1 TO 2N3819 39) CHANGED Q2 TO 2N3819 40) CHANGED Q7 TO 2N2222 (EPL 318) 41) CHANGED Q5 TO 2N2222 (EPL 318) 42) CHANGED Q6 TO 2N5447 43) CHANGED Q3 TO 2N5447 44) CHANGED Q4 TO 2N5447 45) CHANGED Z1 TO SSS741CJ 46) CHANGED A*P6 TO A*P7 47) CHANGED A*P5 TO A*P3	
K	ECN 2380 REV G TO H ADDED 10423 TO N/A	
L	ECN 2380 REV H TO J ADDED 10423 TO N/A	

001	MOD NO.	U/I	SHEET REV	PART NO.

UNLESS OTHERWISE SPECIFIED
DECIMAL XX ± 02 XXX ± 010
ANGULAR ± 1
CONCENTRICITY MACHINED DIAMETERS .004 TIR
ALL DIMENSIONS TO BE MET BEFORE PLATING
REMOVE ALL BURRS AND SHARP EDGES
DO NOT SCALE THIS DRAWING
ALL DIMENSIONS IN INCHES
SURFACES MARKED ✓ TO HAVE ✓
DRILLED HOLE TOLERANCES
.013 TO .136 +.003 −.002
.136 TO .250 +.005 −.003
.250 AND ABOVE ± .005

DR	Michael Lee	8/8/78
ENGR		8/9/78
APPD		8/9/78
	Michael Lee	8/8/78

DESCRIPTION
MENSOR CORPORATION HOUSTON, TEXAS
SCHEMATIC DIAGRAM – AMPLIFIER ASSY
UNIT COMMON
NEXT ASSY 10661
C 10427
D RF10673 AE



REVISIONS

B	NOT RELEASED	
D	ADD [illegible]	
E	ADD [illegible]	
H	ECN 1218 MFG 3-31-82 D400 CHG PER 3-30-82	
K	ECN 82-0274 3-30-82 CHG REV TO ADDR. L WITH P.C.B. ASSY 12276 E.C.O. 12281	
L	ECN 3359 4-1-82 CHG REV TO ADDR. C WITH AN. NO CHG TO DWG.	

- 001	ITEM NO	U/I	DWG SIZE	PART NO.	DESCRIPTION

UNLESS OTHERWISE SPECIFIED
DECIMAL XX ± 02 .XXX ± 010
ANGULAR ± 1°
CONCENTRICITY MACHINED DIAMETERS .004 TIR
ALL DIMENSIONS TO BE MET BEFORE PLATING
REMOVE ALL BURRS AND SHARP EDGES
DO NOT SCALE THIS DRAWING
ALL DIMENSIONS IN INCHES
SURFACES MARKED ✓ TO HAVE
DRILLED HOLE TOLERANCES
.013 TO .136 + .003 − .002
.136 TO .250 + .005 − .003
.250 AND ABOVE ± .005

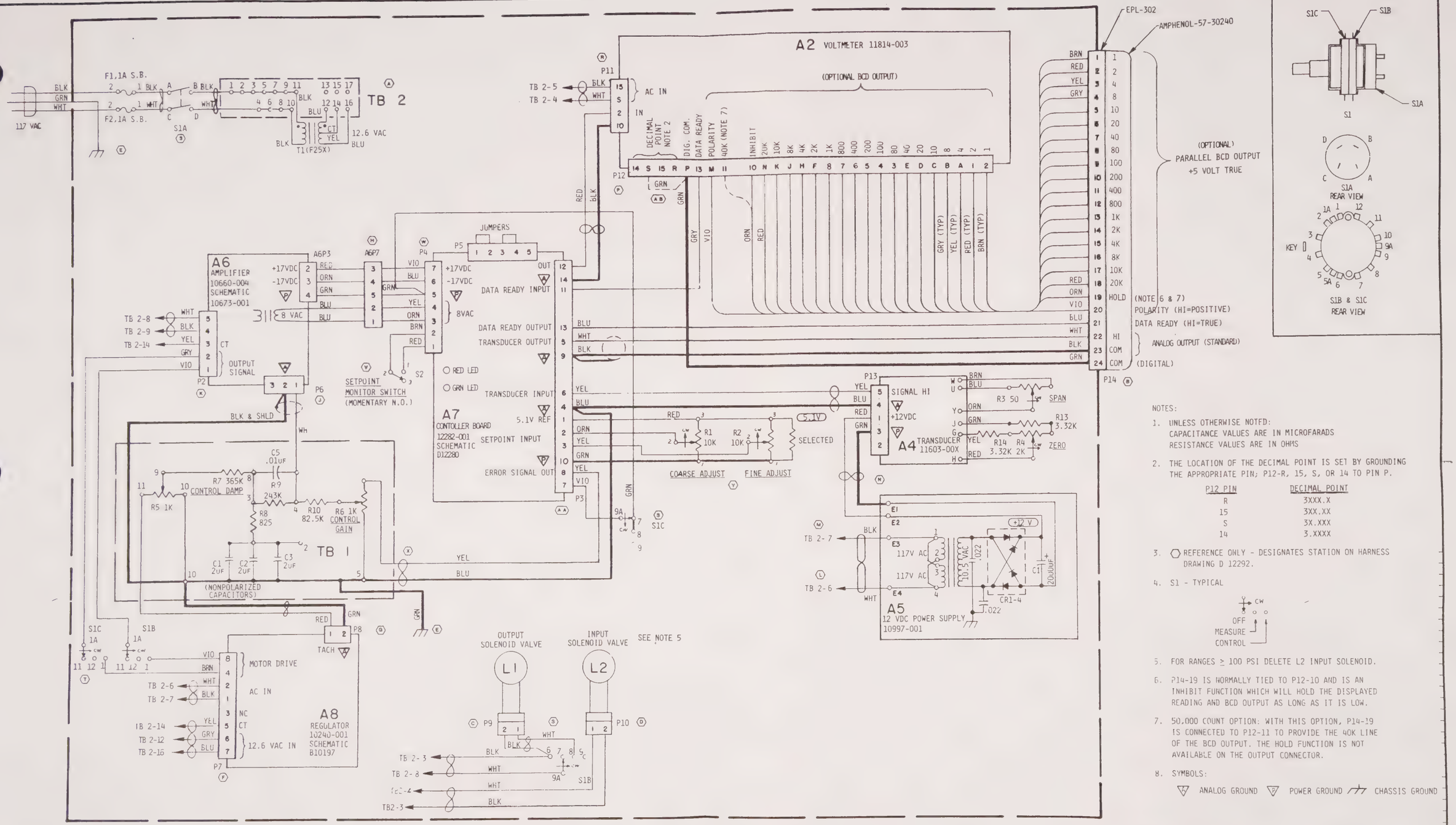
DR 2-29-82 S. Flemming
ENGR
APPD
APPD
RE
PROJ. NO.
SHEET ASSY 12276

MENSOR CORPORATION SAN MARCOS TEXAS

SCHEMATIC DIAGRAM
CONTROLLER BOARD

UNIT: P P C

D | RF12280 | REV L



NOTES:

1. UNLESS OTHERWISE NOTED:
   CAPACITANCE VALUES ARE IN MICROFARADS
   RESISTANCE VALUES ARE IN OHMS

2. THE LOCATION OF THE DECIMAL POINT IS SET BY GROUNDING THE APPROPRIATE PIN; P12-R, 15, S, OR 14 TO PIN P.

P12 PIN	DECIMAL POINT
R	3XXX.X
15	3XX.XX
S	3X.XXX
14	3.XXXX

3. ⬡ REFERENCE ONLY - DESIGNATES STATION ON HARNESS DRAWING D 12292.

4. S1 - TYPICAL

   CW
   OFF
   MEASURE
   CONTROL

5. FOR RANGES ≥ 100 PSI DELETE L2 INPUT SOLENOID.

6. P14-19 IS NORMALLY TIED TO P12-10 AND IS AN INHIBIT FUNCTION WHICH WILL HOLD THE DISPLAYED READING AND BCD OUTPUT AS LONG AS IT IS LOW.

7. 50,000 COUNT OPTION: WITH THIS OPTION, P14-19 IS CONNECTED TO P12-11 TO PROVIDE THE 40K LINE OF THE BCD OUTPUT. THE HOLD FUNCTION IS NOT AVAILABLE ON THE OUTPUT CONNECTOR.

8. SYMBOLS:

   ANALOG GROUND ▽ POWER GROUND ⏚ CHASSIS GROUND

REVISIONS			
LTR	DESCRIPTION	DATE	APPROVED
A			
B			
C			
D			
E			

- 001	ITEM NO.	U/I	DWG SIZE	PART NO.	DESCRIPTION
				UNLESS OTHERWISE SPECIFIED	DR 1-29-93 STEVEN FLEMMING
				DECIMAL .XX ± .02 .XXX ± .010	ENGR 11-16-93
				ANGULAR ± 1°	APPD 11-16-93
				CONCENTRICITY MACHINED DIAMETERS .004 TIR	APPD 12-1-93
				ALL DIMENSIONS TO BE MET BEFORE PLATING	DR 12-17-93
				REMOVE ALL BURRS AND SHARP EDGES	PROV NO. C 10427
				DO NOT SCALE THIS DRAWING	SHEET ASSY D 12275
				ALL DIMENSIONS IN INCHES	
				SURFACES MARKED ✓ TO HAVE	
				DRILLED HOLE TOLERANCES .013 TO .136 + .003 − .002; .136 TO .250 + .005 − .003; .250 AND ABOVE ± .005	

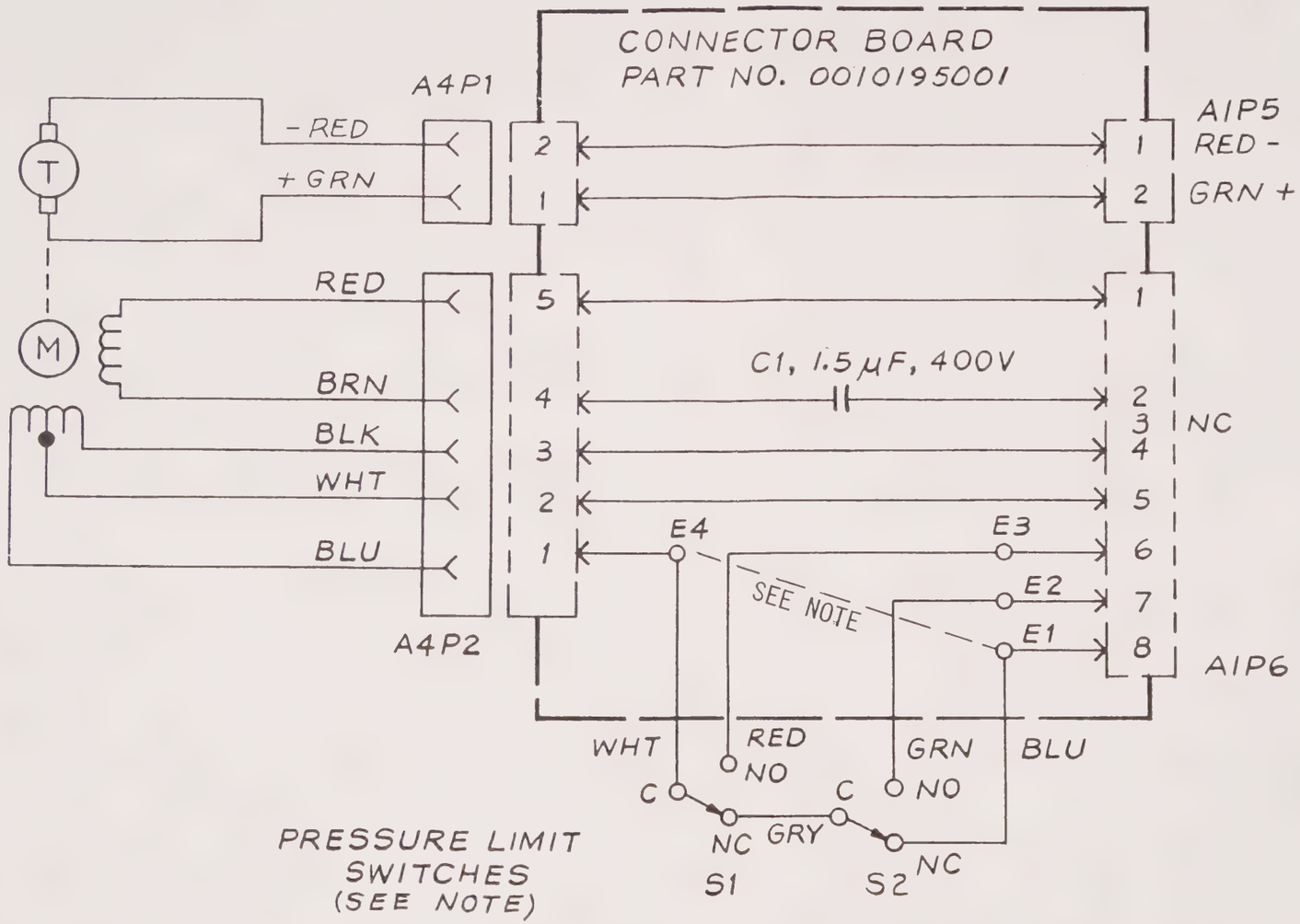
MENSOR CORPORATION SAN MARCOS TEXAS

WIRING DIAGRAM

UNIT: PPC

D RF12285 REV E

NOTE:
FOR REGULATORS WITH MECHANICAL STOPS, A JUMPER IS INSTALLED BETWEEN E1 AND E4, AND LIMIT SWITCHES ARE OMITTED.



REVISIONS

-001	ITEM NO.	U/I	DWG. SIZE	PART NO.

UNLESS OTHERWISE SPECIFIED

DECIMAL .XX ± .02 .XXX ± .010

ANGULAR ± 1°

CONCENTRICITY MACHINED DIAMETERS .004 TIR

ALL DIMENSIONS TO BE MET BEFORE PLATING

REMOVE ALL BURRS AND SHARP EDGES

DO NOT SCALE THIS DRAWING

ALL DIMENSIONS IN INCHES

SURFACES MARKED ✓ TO HAVE ✓

DRILLED HOLE TOLERANCES

.013 TO .136 + .003 − .002 .136 TO .250 + .005 − .003

.250 AND ABOVE ± .005

DESCRIPTION

DR	P. NEILSON	7-13-70
ENGR	R. A. SHEARER	7-25-70
APPD	B. R. S.	12-15-70
APPD	C. W. BUSCHA	12-15-70
REL	P. NEILSON	7-27-70
PROJ. NO.	C 10427	
NEXT ASSY	D10240 B10195	

MENSOR CORPORATION
HOUSTON, TEXAS

ELECTRICAL SCHEMATIC-
REGULATOR ASSY

UNIT: QM/C

B RF10197 REV

- APPENDIX D -

Inserts

NOTE: The calibration chart and the warranty certificate have been enclosed in a separate envelope and shipped with the instrument.

2230 IH-35 SOUTH
SAN MARCOS, TEXAS 78666
(512) 396-4200
TELEX 776487

P/N 12276-001C
25; 7/27/87

ACCO USA
WHEELING, ILLINOIS 60090
22253
MADE IN USA
50505 22253
DK. BLUE/BL. BLEU/AZUL OBSCUR